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Box Patent Application
The Honorable Commissioner
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Sir:

Transmitted herewith for filing is an application of Inventors: Dennis W. Crabtree, Duane J. Brinkerhoff and Dwight P. Williams

For: Improved Fire Fighting Nozzle and Method Including Pressure Regulation, Chemical and Eduction Features

Enclosed are:

31 sheets of drawings. (informal)

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CLAIMS AS FILED

FOR	NUMBER FILED	NUMBER EXTRA	RATE	BASIC FEE $690/$345
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MULTIPLE CLAIMS			X $260/130	
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Serial or Patent No.: ______________
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For: Improved Fire Fighting Nozzle and Method Including Pressure Regulation, Chemical and Eduction Features

VERIFIED STATEMENT (DECLARATION) CLAIMING SMALL ENTITY STATUS (37 CFR 1.9(f) AND 1.27(b)) - INDEPENDENT INVENTOR

As a below named inventor, I hereby declare that I qualify as independent inventor as defined in 37 CFR 1.9(c) for purposes of paying reduced fees under Section 41(a) and (b) of Title 35, United States Code, to the Patent and Trademark Office with regard to the invention entitled **Improved Fire Fighting Nozzle and Method Including Pressure Regulation, Chemical and Eduction Features** described in

- [x] the specification filed herewith
- [ ] application Serial No. __________ filed __________
- [ ] Patent No. __________ issued ______________.

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I acknowledge the duty to file, in this application or patent, notification of any change in status resulting in loss of entitlement to small entity status prior to paying, or at the time of paying, the earliest of the issue fee or any maintenance fee due after the date on which status as a small entity is no longer appropriate. (37 CFR 1.28(b)).

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IMPROVED FIRE FIGHTING NOZZLE AND METHOD INCLUDING PRESSURE REGULATION, CHEMICAL AND EDUCTION FEATURES

Inventors: Dennis W. Crabtree, Duane J. Brinkerhoff
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This application is a continuation-in-part of U.S. Serial No. 09/284,561, filed April 15, 1999, a national stage of PCT/US98/20061, filed September 25, 1998, which is a continuation-in-part of U.S. Provisional Application No. 60/080,846 filed April 6, 1998.

FIELD OF INVENTION

The invention relates to fire fighting and fire preventing nozzles and more particularly to nozzles for extinguishing or preventing large industrial grade fires including flammable liquid fires and/or for nozzles for vapor suppression, and includes improvements in pressure regulating, educting and chemical discharge features, as well as methods of use and apparatus and methods for proportioning or metering foam concentrate into a fire fighting fluid system, in a nozzle or upstream of discharge device(s).

BACKGROUND OF INVENTION

Prior patents relevant to the instant invention include: (1) U.S. Patent No. 4,640 '461 (Williams) directed to a self educting foam fog nozzle; (2) U.S. Patent No. 5,779, 159 (Williams) directed to a peripheral channeling additive fluid nozzle; and (3) U.S. Patent Nos. 5,275,243; 5,167,285 and 5,312,041 (Williams) directed to a chemical and fluid or duel fluid ejecting nozzle. Also relevant is the prior art of automatic nozzles, including (4) U.S. Patent Nos. 5,312,048; 3,684,192 and 3,863,844 to McMilian/Task Force Tips and U.S. Patent Nos. Re 29,717 and 3,893,624 to Thompson/Elkhart Brass. Also of note are U.S. Patent No. 5,678,766 to Peck and PCT Publication WO 97/38757 to Baker.

Maintaining a constant discharge pressure from a nozzle tends to yield a constant range and "authority" for the discharge while allowing the nozzle flow rate to absorb variations in head pressure. In certain applications, such as vapor suppression, a fire fighting nozzle is useful if it self regulates to discharge at an approximately constant or targeted pressure. The discharge pressure tends to govern what is referred to as the "authority" of the discharge stream and to a certain extent the stream's range, and it can affect the delivery of an appropriate vapor-suppressing fog.

One application in which a self-regulating nozzle may be useful, thus, is a protection system that includes nozzles permanently stationed around locales that could be subject to the leakage of toxic chemicals. Upon leakage such a permanently stationed configuration of nozzles, probably under remote control, would be optimally activated to provide a predesigned curtain of water/fog to contain and suppress any toxic vapors. In such circumstances it may be optimal for the nozzles to discharge their fluid with a more or less constant range and authority as opposed to having their discharge structured and regulated for a relatively constant flow rate, as is more common among fire fighting nozzles. Water/fog created with a more or less constant range and authority while operating under the conditions of varying head pressure from a fixed nozzle will tend to more reliably form a curtain in a preselected region, again which may be useful for containing escaping vapors from a fixed locale.

Typically nozzles are structured to deliver pre-set gallon per minute flow rate assuming a nominal head pressure such as 100 psi at the nozzle. As the head pressure actually available to the nozzle in an emergency varies, flow rate remains more consistent with such design than does discharge pressure. Structuring a nozzle to alternately target and regulate its discharge pressure will let flow rate vary more with variations in delivered pressure, but may be an optimal design for certain circumstances.

The present invention, in one important aspect, discloses an improved pressure regulating nozzle designed within its operating limits to effectively discharge a fire extinguishing fluid at a pre-selected or targeted discharge pressure. According to current practice this targeted discharge pressure would likely be approximately 100 psi. It is to be understood, however, that the preselected targeted pressure could be easily varied, and a target pressure might more optimally be selected to be 120 psi. The instant inventive design improves the efficiency of achieving such a target pressure as well as offers a design that more easily combines with self-educting features for foam concentrates and with the capacity to throw fluid chemicals, such as dry powder, from the nozzle.

In another important aspect the present invention teaches enhanced eductive techniques, for peripheral and central channeling, which enhanced eduction can be particularly helpful in automatic nozzles or when also throwing chemical such as dry powder.

A typical automatic nozzle designed in accordance with the present invention would be designed to operate over a range of flow rates, such as from 500 gallons per minute to 2000 gallons per minute, at a targeted discharge pressure, such as 100 psi. To target a discharge pressure, or to self regulate pressure, the nozzle design incorporates a self-adjusting baffle proximate the nozzle discharge. In general, when fluid pressure at the baffle, sensed more or less directly or indirectly, is deemed to lie below target, the baffle is structured in combination with the nozzle to "squeeze down" on the effective size of the discharge port for the nozzle. When pressure build-up at the baffle, as sensed directly or indirectly, is deemed to reach or exceed a targeted pressure, the baffle is structured to cease squeezing down and, if necessary, to shift to enlarge the effective size of the annular discharge port. Such enlargement would continue, in general, until the discharge pressure reduces to the preset target or a limit is reached. Such adjustments in the size of the discharge port cause the flow rate to vary, but the fluid that is discharged tends to be discharged with a more constant "authority" and range, an authority and range associated with the targeted pressure. The instant design is structured to improve the efficiency and reliability of settling upon or around a target pressure.

The instant invention achieves a pressure regulating system by providing a design with an adjustable baffle having what is referred to herein as forward and opposing or reverse fluid pressure surfaces. Pressure from fluid applied to opposing sides of the baffle causes the baffle to respond, at least to an extent, as a double acting piston, although perhaps in a complex manner. The so called forward and reverse directions are referenced to the nozzle axial direction with forward being in the direction of fluid discharge. The forward and reverse pressure surface areas provided by the baffle preferably are not equal. In preferred embodiments the effective pressure surface area of the reverse side exceeds the effective pressure surface area of the forward side. Thus, were the pressure on both surfaces equal, the baffle would automatically gravitate to its most closed position, minimizing or closing the discharge port.

The effective forward pressure surface area will likely, in fact, vary with pressure and with flow rate Limited experience indicates that the forward fluid pressure surface area also varies with bafflehead design and nozzle size. Further, in preferred embodiments, although pressure from the primary fire fighting fluid, directly or indirectly, is applied to both forward and opposing fluid pressure surfaces, the value of the reverse pressure is usually less than, although a function of, the pressure on the forward surface.

A relief valve is preferably provided, such that at or slightly past a targeted pressure the valve can begin to relieve the effective pressure on (at least) one side of the baffle. At least one relief value promises to enhance responsiveness. In preferred embodiments the one side of the baffle upon which pressure is relieved would be the reverse side, the side opposing the forward pressure of the primary fluid on the bafflehead. Specifically, in such an embodiment, when the pressure of the primary fire extinguishing fluid proximate the nozzle discharge causes the pressure sensed by whatever means by the relief valve to exceed a pre-selected value, reverse pressure is relieved on the interior baffle chamber surfaces and the baffle tends to forwardly adjust in response to forward fluid pressure. Alternately, the baffle might simply stabilize at a balanced pressure position in preferred embodiments, with or without the (or a) relief valve slightly bleeding. That is, a nozzle could be designed to achieve a balanced pressure baffle position with or without a relief valve and with or without any bleeding of a relief valve. Use of at least one relief valve, and a bleeding relief valve, are practical expedients.

To continue the prior example, adjustments forward of a bafflehead may continue until the primary forward fluid pressure at the bafflehead, as sensed directly or indirectly, decreases to or diminishes below a preset relief valve value. Thereupon a closing of the relief valve would be triggered. The bafflehead might stabilize, or if stabilization were not achieved, could adjust backwardly with the relief valve either bleeding or closed, depending on the design, thereby decreasing the effective size of the nozzle discharge port.

To summarize operations, as the bafflehead adjusts forward and backward, as described above, the discharge pressure declines and increases, respectively. If a discharge pressure declines to, or below, a pre-selected amount, as sensed directly or indirectly, in preferred embodiments as described above, a relief valve would be set so that it tends to close. Closing the relief valve would increase reverse pressure on the baffle. Alternately if a sensed delivered pressure is deemed to increase above a preselected amount, the (or a) relief valve would preferably be set so that it tends to open. With the assistance of the opening and closing of a relief valve, a bafflehead can be encouraged to quickly and efficiently gravitate toward a balanced location wherein the effective pressure on the bafflehead in the forward direction offsets the effective pressure on the bafflehead in the reverse direction, taking into account the degree of openness, and any bleeding, of a relief valve or valves, as well as other factors of the design and the supplied pressure. Of course, other biasing factors on the bafflehead, such as springs, etc. could be present and would have to be taken into account.

Again, assuming that the reverse pressure surface area afforded by the bafflehead chamber is larger than the effective forward pressure surface area afforded by the bafflehead, and that the reverse side of the baffle is supplied with a measure of fluid pressure from the primary fire fighting fluid as delivered to the nozzle then a bafflehead and nozzle could be designed (ignoring the effects of any relief valve activation) so that as the pressure of the fire extinguishing fluid through the nozzle decreases, the bafflehead adjusts in the reverse direction until it either closes or hits a stop or balances (or triggers a relief valve). Squeezing down on the size of the discharge port raises discharge pressure. Again, as stated above, a design could incorporate, without any relief valves, a balanced pressure position where, at target pressure, the effective pressure on the baffle forward pressure surface offsets the effective pressure on the opposing reverse baffle surface. The design would take into account the fact that the pressures and the areas would be different and would typically vary. In general, however, the bafflehead forward surfaces and reverse surfaces together with the nozzle discharge structure, baffle structure and any relief valves and any other supportive biasing means, should be designed and structured in combination such that a targeted discharge pressure is effectively and efficiently achieved without undue hunting. As mentioned above, a relief valve or valves likely improve the efficiency of the design and, at the balance point, might be optimally structured to be slightly open, or bleeding.

Further to summarize operations, pressure forward on the bafflehead is the product of the delivered fluid pressure at the effective bafflehead deflecting surface times the effective baffle forward surface area. The opposing pressure on the bafflehead is the fluid pressure developed against the bafflehead opposing surface (preferably the primary fluid operating within a baffle chamber) times the opposing bafflehead surface area. The opposing surface area is preferably larger than the effective forward surface area, and reverse fluid pressure, such as developed within a baffle chamber, is likely less than, although a function of, the delivered fluid pressure at the bafflehead. As stated above, while it is possible to design a self adjusting bafflehead in combination with a nozzle structure such that a bafflehead balances at a targeted pressure without the assistance of any relief valves, a relief valve likely facilitates the speed, sensitivity and efficiency of the design for most nozzle sizes. So, using one or more relief valves, a valve trigger pressure would be selected such that, when fluid pressure on forward baffle surfaces appears to a sensing device to begin to significantly exceed the target pressure, the relief valve opens or at least begins to open. At such point the valve relieves or begins to relieve fluid pressure on one baffle surface, such as the reverse surface, allowing the baffle to stabilize or to begin to readjust. The readjustment affects fluid discharge pressure at the discharge port. One preferred design includes structuring of bafflehead surface area and a relief valve in combination such that with the relief valve closed, the bafflehead essentially closes the nozzle; further, the bafflehead balances at a targeted delivery pressure with the relief valve partially open or bleeding. With the relief valve completely open, the bafflehead would move to its fully open position.

The present invention has at least three objectives. One objective is to provide an automatic self adjusting nozzle that can accurately, speedily and reliably control nozzle discharge pressure to within a small range. A second objective is to provide a self adjusting nozzle design that adjusts smoothly and accurately in both directions, that is both from a too high pressure situation and from a too low pressure situation toward a target pressure. Structure to accomplish these two objectives has been discussed above. Third and further objectives are to provide an enhanced self educting nozzle design, valuable in its own right and also so that a self-adjusting nozzle can be efficiently combined and incorporated into a self-educting foam/fog nozzle. In addition the enhanced eductive design is useful to incorporate with a nozzle incorporating a capacity for throwing fluid chemicals, such as dry powder. Thus, the invention also relates to improved educting features applicable to various nozzles. The invention also includes methods and apparatus for metering a chemical, such as a foam concentrate, into a variably flowing fire fighting fluid conduit at the nozzle, or upstream from a nozzle device or devices.

SUMMARY OF THE INVENTION

The invention includes a pressure regulating nozzle for extinguishing fires comprising a baffle adjustably located proximate a nozzle discharge. The baffle provides forward and opposing pressure services in fluid communication with a primary fire extinguishing fluid. The baffle adjustment is affected, at least in part, by fluid pressure upon the forward and opposing baffle surfaces.

Preferably the nozzle includes a relief valve and the effective opposing pressure surface areas of the bafflehead are larger than the effective forward pressure surface areas. Preferably the baffle defines a baffle chamber and the relief valve, if one is utilized, is located at least partially within the baffle chamber.

The invention includes incorporating fluid educting features into the self adjusting nozzle. The fluid educting features are designed particularly for foam concentrate and could provide either central or peripheral channeling of the foam concentrate.

Preferably also the present invention provides for incorporating a capacity to throw dry chemical with the self adjusting nozzle and the self adjusting and self educting nozzle.

The invention also provides for enhanced educting features when the second fluid or foam concentrate is channeled peripherally around the wall. These enhanced educting features could be utilized with or without a self adjusting bafflehead. The enhanced educting features include shaping the primary fire fighting fluid stream proximate a nozzle discharge to form an annular stream having a gradually diminishing cross sectional area. The eductive port for the second fluid or foam concentrate opens onto the annular stream just downstream of the minimum of the cross sectional area. The annular stream gradually expands subsequent to reaching the minimum. Additionally small jets for the primary fire fighting fluid may be provided through the peripheral channeling walls to enhance eduction of the second fluid or foam concentrate. The invention further includes automatic self proportioning of an additive, such as foam concentrate, into a conduit flowing fire fighting fluid with a variable flow rate, either at a nozzle or upstream from a discharge device.

BRIEF DESCRIPTION OF THE DRAWINGS

A better understanding of the present invention can be obtained when the following detailed description of preferred embodiments are considered in conjunction with the following drawings, in which:

Figure 1 illustrates in cutaway form, for background purposes, typical structure of a prior art self-educting nozzle that is not self-adjusting.

Figure 2A illustrates in cutaway form one embodiment for a self-adjusting nozzle, the embodiment having a centralized relief valve.

Figure 2B illustrate in cutaway form an enlarged detail of Figure 2A, namely an embodiment of an adjustable bafflehead with a centrally located pilot relief valve.

Figure 2C illustrates one embodiment of a pilot relief valve assembly.

Figure 2D also illustrates in cutaway form an embodiment for a self-adjusting nozzle having a non centrally located pilot relief assembly.

Figure 3A illustrates in cutaway form an embodiment of a self-educting and self-adjusting nozzle, including transporting and discharging foam concentrate through the center of the nozzle and having a pilot relief assembly that senses pressure within a baffle chamber.

Figure 3B illustrates in greater detail a pilot relief assembly as in Figure 3A wherein pressure is sensed within a baffle chamber.

Figure 3C illustrates an embodiment of an automatic nozzle that provides for educting foam concentrate and for peripherally channeling the educted foam concentrate; a pilot relief assembly is illustrated that senses pressure along forward bafflehead surface areas.

Figure 3D illustrates in cutaway form an embodiment of an automatic nozzle providing for educting foam concentrate with central channeling for the foam concentrate; a pilot relief assembly is illustrated that senses pressure at a baffle forward surface area.

Figure 3E illustrates in cutaway a detail of Figure 3D, namely, a non-centrally located pilot relief assembly for sensing pressure at a baffle forward surface area.

Figure 4A is included primarily to illustrate one possible location for a flow meter within an embodiment of the present invention; in Figure 4A a self-educting pressure regulating nozzle is indicated where a relief valve has been designed as an annular relief valve encircling the tube that provides educted fluid into a mixing type area of the nozzle. A flow meter is illustrated having an attachment to a visible indicator on the outside of the nozzle, the flow meter itself indicated as residing within the baffle.

Figure 4B illustrates an alternate embodiment of the invention wherein a baffle chamber slides over a fixed stem and a fixed piston and a spring located on a fixed stem, the piston being substituted for a relief valve and other embodiments and the spring alternately biasing the piston either out or in depending upon design.

Figure 4C illustrates in cutaway form an embodiment of an automatic nozzle providing for transporting and discharging a fluid chemical, such as a dry powder, through the center and providing a relief valve triggered on baffle chamber pressure.

Figure 4D illustrates in cutaway form an embodiment of an automatic nozzle providing for centrally discharging a fluid chemical with a relief valve triggered on forward baffle surface fluid pressure.

Figure 5A illustrates in cutaway form an embodiment of an automatic nozzle providing for enhanced educting and channeling foam concentrate peripherally and for discharging a fluid chemical centrally.

Figure 5B illustrates in cutaway form an embodiment of an automatic nozzle providing for educting foam concentrate peripherally and discharging a fluid chemical centrally, the embodiment of 5B also including a jet for assisting the educting of the foam concentrate.

Figure 5C illustrates an embodiment of an automatic nozzle providing educting foam concentrate peripherally and discharging fluid chemicals centrally, and having a further type of jet eductor for the foam.

Figure 6 illustrates in cutaway an automatic nozzle wherein foam concentrate and fluid chemical are both channeled through the nozzle centrally.

Figure 7 illustrates an embodiment of an automatic nozzle providing for educting foam with enhanced peripheral discharge.

Figure 8 illustrates a nozzle similar to the embodiment of Figure 7, but without the automatic feature.

Figure 9 illustrates an enhanced educting discharge feature wherein the foam concentrate is transported centrally.

Figures 10A and 10B illustrate automatic foam proportioning devices similar to that of Figure 3A in a fire fighting fluid conduit, the devices offering eduction.

Figures 11A, 11B and 11C illustrate an automatic foam concentrate proportioning device in a fire fighting fluid conduit having variable flow, the device not utilizing an upstream venturi for eduction, and the device utilizing an exterior control pilot valve.

The drawings are primarily illustrative. It should be understood that structure may have been simplified and details omitted in order to convey certain aspects of the invention. Scale may be sacrificed to clarity.

Detailed Description of the Preferred Embodiments

In general, a nozzle having an "adjustable" baffle in order to discharge fire extinguishing fluid at a targeted pressure requires a biasing means opposing a natural movement of an adjustable baffle outwards in response to fluid pressure, which outward movement tends to open the effective size of the discharge port. Most simply the biasing means biases with a backward force equal to the force of the desired or targeted fluid pressure upon the forward baffle surfaces. Hence baffle forward movement balances against baffle backward bias pressure at the targeted pressure. Forward baffle surfaces are surfaces that the baffle presents to the fire extinguishing fluid moving through and out of the discharge port. In theory, the biasing force could be provided by a spring that, over the adjustment range of the baffle between its end points, which may be no more than approximately one half of an inch, presents an essentially constant biasing force at the targeted pressure. The target pressure might well be 100 psi. Such simple design is indicated in figure 4B.

Alternately, an adjustable bafflehead could be designed defining a chamber within the bafflehead and presenting forward and backward surfaces against which the primary fire extinguishing fluid could act. It is understood that the chamber defined within the bafflehead would have means for permitting a portion of the fire extinguishing fluid to enter the chamber. In such designs the effective backward pressure surface area would usually exceed the effective forward pressure surface area of the baffle. The fluid pressure within the baffle, however, is expected to be at least slightly less than the pressure exerted on forward facing baffle surfaces. Such tends to counter the fact that the backward pressure surface area presented to the fluid within the baffle, at least in preferred embodiments herein, exceeds the forward pressure surface area presented on the baffle. In such manner the fluid within the baffle acts against a greater surface area and, although lower in value, can potentially drive the baffle backwards against the flow of fluid through the nozzle. Anticipating the difference between the pressures, without and within the baffle, at different source pressures, and anticipating the difference in the effective areas presented to the fluid pressures at different head pressures and flow rates, leads to a design for a "balanced baffle" at a targeted fluid pressure. Spring mechanisms can always be added, it should be understood, to augment the biasing forces provided by the primary fire extinguishing fluid pressure upon the bafflehead forward and backward surfaces.

It should be understood that if or when baffle adjustment results in a variation of the volume of the defined baffle chamber, as by the baffle sliding over a fixed piston, relief will be provided to vent fluid from inside the chamber.

The present invention discloses in particular the use of at least one relief valve in order to heighten the accuracy and speed of balance and to lessen undue hunting or hysteresis. A relief valve vents fluid pressure from one or the other side of the baffle, preferably from within the baffle chamber, when fluid pressure varies from target pressure. Such venting typically causes the baffle to move, as in an illustrated case, outward toward one of the baffle location end points. A movement outward or toward the outward end direction will cause a decrease in the fluid pressure upon the baffle. Such decrease in fluid pressure could cause the relief valve to again close, permitting again the buildup of fluid pressure upon the back side of the baffle. The build up of fluid pressure upon the back side of the baffle should help adjust the baffle toward a balanced position where the fluid pressure on the forward surfaces of the baffle balances the fluid pressure on backward surfaces of the baffle, including taking into account other biasing elements such as a continuously "bleeding" relief valve and any springs utilized in the design.

The relief valves illustrated for the instant embodiments sense either rather directly the primary fire extinguishing fluid pressure presented to forward baffle surface areas in the nozzle or sense more indirectly a more secondary fluid pressure generated within a chamber within the baffle. The difference between such designs, or other designs that could occur to those of skill in the art, can largely be a matter of design choice and simplicity of engineering.

One function selected for a relief valve could be to assist in achieving the situation where a balanced pressure position is consistently approached from the same direction, which could either be the moving outwardly or the moving inwardly the baffle. Such a design may facilitate engineering a higher degree of accuracy around the balance point with less hunting and greater speed in achieving balance.

The present invention also teaches improved self educting features that are particularly helpful and useful in a pressure regulated nozzle, as well as enhanced educting and pressure regulating designs that are useful when throwing fluid chemical such as dry powder, with or without an automatic nozzle.

Figure 1 illustrates a standard self educting nozzle. FEF indicates a fire extinguishing fluid. Fire extinguishing fluid FEF educts foam concentrate FC by means of eductor E into central fixed stem FS of nozzle N. The mainstream of the fire extinguishing fluid FEF, which is usually water W, flows by fins F, is deflected outwardly by forward baffle deflecting surface 20 and flows out the gap or nozzle discharge part P. Foam concentrate FC and a small amount of fire extinguishing fluid FEF that flows through eductor E by means of jet nozzle J flows through the stem and past mixing plate M, thereafter to mix with the main body of fire extinguishing fluid FEF flowing out of the gap or port P in the nozzle into mixing area 22. Sleeve S adjusts from a backward position shown in Figure 1, for throwing a fog pattern, to a forward position for throwing a "straight stream" pattern. Port P is defined by surface 20 of baffle B and by surface 21 of nozzle N. Nozzle N can be an assembly of parts.

Figures 2A, 2B and 2C illustrate a pressure regulating or self-adjusting or automatic nozzle N built using a basic structure of a self educting nozzle, but with the foam eduction inlet closed off by module 32. (Photos in the provisional application, above referenced, illustrate the embodiment of figures 2A, 2B and 2C. The photos include the springs utilized.) Figures 2A, 2B and 2C are particularly useful in disclosing one embodiment of the automatic pressure regulating feature. The nozzle of figures 2A, 2B and 2C enjoys the simplicity that it is neither self-educting nor is structured to throw dry chemical. In the embodiment of figures 2A, 2B and 2C pilot or relief valve 42 is utilized. The simple design permits the pilot or relief valve to be centered in the stem of the nozzle. Were the center of the nozzle to be utilized to channel either foam concentrate or dry chemical, then a pilot valve associated with the self-adjusting baffle would be better located off center on the baffle. Such alternate design is illustrated in figure 2D, which is also an embodiment of an automatic nozzle without provision for either educting foam or throwing dry chemical, although it could easily be modified to do so. It can be seen that the automatic feature design of figure 2D lends itself to educting foam concentrate or channeling dry chemical through the center of the nozzle.

Nozzle N of figure 2A illustrates adjustable bafflehead B sliding over fixed support stem 28. Support stem 28 is anchored in stem adapter 29. Fire extinguishing fluid FEF or water W enters nozzle N from the left and flows to the right, exiting port P between surface 20 defined by bafflehead B and surface 21 defined by an element of nozzle N. Provision is made for fire extinguishing fluid to enter the center of support stem 28 thereby pressuring a surface of pilot 42 located essentially within bafflehead B. Pilot 42 presents pilot pressure surface port 40 to expose a pressure sensing surface to the fire extinguishing fluid or water that enters the support stem 28 of nozzle N.

Piston 26 at the end of support stem 28 is fixed, like support stem 28. Bafflehead B defines a baffle chamber 24 within interior portions of bafflehead B, utilizing fixed piston 26 to form one end of the chamber. A filter 34 is preferably provided to the water inlet of support stem 28 to keep debris from blocking the pilot pressure surface in port 40. Flanged base 36 is known in the art as a means for connecting a nozzle N to a supply of fire extinguishing fluid or water. Filter 34 can be retained by filter retaining nut 35.

Figure 2C more clearly illustrates the operation of pilot valve 42. Fire extinguishing fluid FEF is present within fixed stem 28 and presses upon pilot control surface 41 within sensing pressure inlet port 40. Fire extinguishing fluid FEF also enters bafflehead B interior chamber 24 via side inlet ports 58 as illustrated by the arrows in figure 2C. Side inlet ports 58 of the embodiment of figure 2C are on the outside of pilot control surface 41. Sliding bafflehead B, sliding over fixed piston 26, is pushed forward by the pressure of fire extinguishing fluid against forward baffle surface 20 and is pushed backwards by the pressure of fire extinguishing fluid within baffle chamber 24 against reverse or opposing bafflehead surfaces 23. In operation reverse surfaces 23 in the embodiment of figure 2C present a greater effective surface area than forward bafflehead surfaces 20, when taking into account the flow of the fluid, from bottom to top in figure 2C, past bafflehead B. A bafflehead reset spring 50 is shown which resets the bafflehead to its closed position absent overriding water pressure. The pressure of the fire extinguishing fluid inside bafflehead chamber 24 is less than the pressure of the fire extinguishing fluid upon forward surfaces 20 of bafflehead B, as determined by testing.

Pilot control surface 41 in pressure inlet port 40 is biased by pilot bias spring 48. Pilot bias spring 48 sets the value at which the pilot valve opens or at least bleeds. When the pressure against pilot control surface 41 creates a force that overcomes the biasing pressure of pilot bias spring 48, the piston of pilot valve 47 with pilot seal 45 moves forward in the direction of nozzle flow, opening pilot valve 47. Fire extinguishing fluid FEF within bafflehead 24 enters ports and fills chamber 62 within pilot valve 42. When pilot valve 47 opens, fluid from pilot valve chamber 62 flows through pilot valve chamber 64 and further forward and out atmospheric vent holes 56. Piston retaining nut 46 holds fixed piston 26 on fixed stem 28. Floating bafflehead B slides past fixed piston 26 and is sealed by main seal 54 against the surface of fixed piston 56. If or when pilot valve 47 only opens a slight amount then pilot 42 will bleed or leak slowly through chambers 62, 64 and out atmospheric vent holes 56. As fluid is allowed to move out of bafflehead chamber 24 through chamber 62 and chamber 64 and atmospheric vent holes 56 within the pilot valve, pressure is relieved against opposing or reverse interior bafflehead surface 23. As pressure is relieved against surface 23 the force of fire extinguishing fluid pressure against surface 20 can slide bafflehead B forward over fixed piston 26. Guide element 43 of pilot valve 42 serves to guide the movement of the piston of pilot valve 47 within pilot valve 42. Guide 43 can be sealed against fixed stem 28 with guide seals 49. Spring tension adjustment screw 44 can be provided to vary the bias of pilot bias spring 48.

Figure 2D illustrates an analogous sliding adjustable bafflehead B having an off center pilot relief assembly 42. Pilot relief assembly 42 senses pressure at portions of forward baffle surface 20 of sliding bafflehead B. Pressure is sensed through a sensing pressure inlet port 40 provided for pilot relief assembly 42. Flow indicators 70 are illustrated in Figure 2D utilizing sensors 74 and 72 to give a visual indication and readout of flow to operator. Water inlets 58 in Figure 2D provide ingress into interior bafflehead chamber 24 for the primary fire extinguishing fluid in order to create a reverse pressure or backward pressure against sliding bafflehead B.

Figures 3A and 3B illustrate a self educting pressure regulating nozzle where foam concentrate FC is channeled centrally through slidable flow metering tube 96 and fixed stem 28. In the preferred design of figures 3A and 3B water W, the typical primary fire extinguishing fluid, enters baffle chamber 24 by means of water inlets 58, passing from the forward surface 20 of the bafflehead B into the chamber 24 and around the backward facing surface 23 of bafflehead B. The pilot relief valve assembly 42 of the embodiment of Figure 3A senses pressure of the fire extinguishing fluid or water W within the baffle chamber 24. Figure 3B offers an enlargement of pilot relief assembly 42 of figure 3A. In the instant design the pilot relief valve or poppet valve 47 is spring biased by pilot bias spring 48 so that the poppet 47 moves from its seat 45 and relieves pressure at one selected relief valve pressure, which in preferred embodiments might be set at about two thirds of a targeted 100 psi nozzle head pressure. Such a value, experience has indicated, is appropriate for a relief valve sensing fire extinguishing fluid pressure within a baffle chamber of a nozzle. The spring biasing pressure set for fluid pressure within the baffle chamber, as in figure 3B, existing tests and experience indicate, would run appropriately 65 psi in order to reach the proper balancing of inward and outward fluid pressure upon forward and backward baffle surfaces to achieve a target pressure of approximately 100 psi while taking into account other biasing such as may be used to return a baffle to a closed position with no flow of water therethrough.

In Figure 3B when force against pilot control surface 41 is greater than the force of pilot spring 48, pilot relief valve 47 opens emitting fluid from within baffle chamber 24 to flow through pilot relief valve or poppet chamber 64 and out atmospheric vent holes 56. Again, depending upon design, intent and the pressures involved, the pilot relief valve might bleed slightly or open fully.

Figure 3A incorporates a slidable flow metering tube 96 that slides with bafflehead B over fixed stem 28. Flow metering tube 96 slides over fixed foam metering orifice 94. Foam metering orifice 94, according to its degree of openness, affects the amount of foam educted through foam inlet 90 by water W proceeding through inlet jet 92 and through eductor jet J. In such manner, the relative position of the sliding bafflehead B over stem 28 and within nozzle N can effect the metering or the amount of foam educted through stem 28 and tube 96. Figure 3A further illustrates the option of adding a gauge float assembly 98 connected to a gauge feed pump assembly 100. Foam concentrate FC flows through foam inlet 90 and into stem 28 through foam metering orifice 94. The degree of openness of foam metering orifice 94 depends upon the relative longitudinal setting of bafflehead C and connected foam metering tube 96.

The embodiments of Figures 3D and 3E are similar to the embodiments of Figures 3A and 3B. The difference is that pilot relief assembly 42, in the embodiments of Figures 3D and 3E, senses water pressure more or less directly at floating bafflehead B forward surface 20.

The embodiment of Figure 3C illustrates an automatic nozzle providing for self educting foam concentrate but peripherally channels the foam concentrate around portions of the nozzle barrel wall, in lieu of centrally channeling the foam. The central stem in Figure 3C is illustrated as solid. The central stem could, of course, be utilized as a channel for channeling chemical such as dry powder through the nozzle.

The pilot relief assembly 42 of the embodiment of Figure 3C is similar to that of the embodiment of Figure 3D. Bafflehead B slides on fixed support stem 28 as in the embodiment of Figure 2A. Again a flow indicator 70 is illustrated for providing a visual readout of flow through the nozzle. In the embodiment of Figure 3C foam concentrate FC enters foam inlet 90 and is channeled through peripheral channels 52 to the discharge end of nozzle N. Foam concentrate FC follows a path through peripheral channels 52, which could well be an annular channel ending an annular foam outlet 27. An enhanced or improved educting feature is illustrated in Figure 3C. Nozzle surface 21 and bafflehead surface 20 serve to shape the exiting water stream W. Water stream W is shaped by surfaces 21 and 20 to form a relatively smooth annular stream with a diminishing width across sectional areas down to a minimum width achieved just prior to passing over and past foam outlet 27. The cross sectional width of the annular stream of the water slightly widens when and after passing foam outlet 27. This accommodates the small amount, typically 3 to 6 percent, of foam concentrate educted into the major water stream W. Water W and the appropriate amount of foam concentrate FC then exit together at port P, the foam concentrate being educted through foam outlet 27 by the passage of water W through the minimum point having width 220, port gap or port P and out into general mixing area 22. Mixing area 22 is indicated rather amorphously by dashed lines. Tests and experience have indicated that the educting force achieved by water W passing over foam outlet 27 is enhanced when the exiting stream is shaped into a relatively smooth annular stream with a diminishing cross sectional area in region 222 over a distance of approximately two times to five times the width 226 of foam outlet 27.

Figure 4A illustrates one possible location of a flow meter within an embodiment of the present invention. In figure 4A a self-educting pressure regulating nozzle is indicated where a relief valve has been designed as an annular relief valve encircling the tube that provides educted fluid into the mixing plate area of the nozzle. A flow meter is illustrated having an attachment to a visible indicator on the outside of the nozzle. The flow meter itself is indicated as residing within the baffle. Another optional location for a flow meter is simply along the inside wall of the nozzle.

Figure 4B illustrates an embodiment of the invention that was tested but did not yield the accuracy of the relief valve. In figure 4B a baffle chamber is shown having a baffle that slides over a fixed stem and a fixed piston. The baffle defines a baffle chamber with backward baffle surfaces. Fluid in the baffle chamber operates backwards against the baffle while the fire extinguishing fluid flowing through the nozzle acts against the baffle forward surfaces for forward pressure against the baffle. In the embodiment of figure 4B a spring located around the fixed stem and piston is substituted for the relief valve. The spring could bias the piston either out or in depending upon the spring design.

Figure 4C illustrates a self adjusting nozzle designed for also throwing a chemical such as a dry powder. Chemical inlet 110 provides a basis for chemical C to enter the nozzle and be centrally channeled through fixed stem 28 and channel 112 in order to be discharged out the front of the nozzle. Pilot relief assembly 42 is illustrated in the embodiment of Figure 4C to be similar to pilot relief assembly 42 of Figure 3A. The embodiment of Figure 4D is again an automatic pressure adjusting nozzle providing for throwing a chemical such as dry powder that is centrally channeled through the nozzle. The embodiment of 4D differs from the embodiment of 4C in that pilot relief assembly 42 senses pressure on forward surfaces 20 of bafflehead B as opposed to interior surfaces of bafflehead chamber 24.

The embodiment of Figure 5A combines an automatic nozzle that centrally channels and throws dry chemical, such as the embodiment of Figure 4D, with peripheral channeling for foam concentrate such as the embodiment of 3C. Further the eduction for the foam concentrate is enhanced as in the embodiment of Figure 3C.

The embodiment of Figure 5B is similar to the embodiment of Figure 5A except a foam jet JJ is provided to enhance the eduction of foam concentrate FC into peripheral channels 52 of nozzle N, and the enhanced eduction discharge design of Figure 3A is not utilized. The embodiment of Figure 5C provides an alternate version for the embodiment of Figure 5B wherein foam jet JJ utilizes an alternate design.

The embodiment of Figure 6 centrally channels both foam concentrate and dry chemical while providing a self adjusting bafflehead.

The embodiment of Figure 7 is analogous to the embodiment of Figure 3C with the difference that foam jets 200 provide for further enhanced eduction of foam concentrate FC through foam inlet 90 and out foam outlets 27.

Figures 8 and 9 illustrate nozzles that are not self adjusting. The nozzles of Figure 8 and Figure 9 have a fixed bafflehead FB. Figure 8 illustrates the value of enhanced educting features even in a nonpressure regulating fixed bafflehead nozzle. Foam jet inlet ports 200 are illustrated jetting small portions of water flowing through the nozzle into annular chamber foam paths 52. Surfaces 21 and 20 are shown shaping a relatively smooth annular stream with diminishing cross section for the water just prior to passing over foam outlet 27 at the discharge end or port P of nozzle N. Figure 9 illustrates the enhanced self educting feature for centrally channeled foam concentrate FC. In Figure 9 surfaces 21 and 20 again shape a relatively smooth annular stream of water just adjacent passing over foam port 27, the relatively smooth annular stream of water having a slightly diminishing cross section area down to a minimum area just prior to passing over foam concentrate port 27.

In operation, as discussed above, the self-adjusting automatic feature of the present invention depends upon an adjustable baffle that adjusts, at least in significant part, in response to primary fire fighting fluid pressure presented both to a forward and a reverse side of a baffle surface. In such a manner the baffle operates at least in part as a two-way piston seeking a balanced pressure position. The nozzle fluid provides a fluid pressure to act against both sides of the baffle. The pressure acting in the reverse direction will be at least a function of the forward pressure. Preferably the reverse pressure surface of the baffle will be larger than the forward pressure surface of the baffle. It is recognized that the forward pressure surface of the baffle may in fact change and be a function of pressure and fluid flow through the nozzle and baffle design and nozzle size. Although it would be possible to design a baffle having a balanced position where the targeted pressure forward times the forward pressure surface equals the reverse pressure times the reverse pressure surface, such a balancing technique is difficult to effect in practice. Hence, preferred embodiments of the present invention utilize at least one relief valve. Preferred embodiments further utilize a relief valve to relieve pressure in the reverse direction. In preferred embodiments the area of the reverse pressure surface is greater than the area of the forward pressure surface. Thus, in preferred embodiments when the relief valve is closed, in general, the reverse pressure times the area of the reverse pressure surface will be greater than the forward pressure times the area of the forward baffle surface. This will dictate that for significant values of forward pressure the nozzle is biased closed. As the baffle closes, the pressure forward at the bafflehead will tend toward its maximum deliverable pressure in the nozzle. At some point near the forward target pressure, one or more relief valves begin to open relieving pressure on the reverse side of the baffle and allowing the bafflehead to balance onto open and adjust outward. Preferably the relief valve builds in a degree of adjustability such that the relief valve can select a partially opened position and settle upon such position without undue hunting and wherein the target pressure times the forward surface at the target pressure equals the reverse pressure times the reverse pressure surface area taking into account the degree of openness of the relief valve system.

The invention also relates to a foam proportioning or metering device, *per se*, for a fire fighting fluid conduit having varying fluid flow rates. The conduit could comprise a nozzle, as illustrated in Figure 3A. The device is useful, however, for any conduit in a fire fighting system, such as in a fixed sprinkler system or on a fire fighting truck. That is, the metering device invention need not be proximate a discharge orifice. A baffle or piston or obstruction (baffle/piston) creating a pressure drop for metering purposes need not be creating at the same time a nozzle discharge pressure.

The existence of significantly varying fire fighting fluid flow rates in a conduit in a system providing fire fighting fluid and foam concentrate to a discharge orifice (or orifices) raises a problem for the proper metering of foam concentrate into the fire fighting fluid. Foam concentrates are usually designed and supplied to be mixed with water (the usual but not necessarily the only fire fighting fluid) at a fixed percent, typically 3% or 6%. For any system, if the fire fighting fluid flow rate can vary significantly, such as twofold or tenfold or even one hundredfold, securing proper and reliable metering is an issue.

Venturi devices are known as proportioning devices, creating pressure drops that vary with fluid flow rate in order to proportion foam concentrate into a fire fighting fluid conduit in accordance with a varying fire fighting fluid flow rate. These venturi devices, such as a Williams' Ratio Controller, accomplish this task with a certain degree of accuracy and efficiency. In general, the greater the fire fighting fluid flow rate the greater the pressure drop through the venturi, thus drawing in a greater amount of foam concentrate. However, such venturi devices alone are not accurate at low flow rates, as is known, and their efficiency decreases with high flow rates. The efficiency drops because total pressure drop is in proportion to flow rate and pressure recovery downstream is limited to a maximum efficiency range in the order of 65% to 85% of the pressure drop. Thus, the higher the flow, the greater the pressure drop, the less pressure recovery and the more limited the efficiency.

In preferred embodiments of the instant invention, pilot valves are a preferred means to maintain a preselected or predetermined pressure drop across a variety of fire fighting fluid flow rates in a conduit. (The pressure drop may or may not be constant, or even approximately constant, across a range of fluid flow rates.) Preferred embodiments propose the use of lower and more constant pressure drops, as permitted under the circumstances, in order to efficiently proportion foam concentrate into a fire fighting fluid.

The invention teaches a means for using a variable fire fighting fluid orifice in a conduit to serve as a measure or indicator of fire fighting fluid flow rate and to coordinate such variable orifice with a variable foam concentrate orifice in order to meter concentrate. A pilot valve is not essential to maintain any pressure drop of the instant invention. Its reliability is high, however, and its complexity is likely to offset in most applications the loss of efficiency associated with less complex devices such as straightforward biasing springs. Analogously, in the automatic pressure regulating nozzles discussed above, pilot valves were preferred over simple biasing springs.

The foam proportioning or metering device of the instant invention utilizes a first adjusting element (such as a piston or a baffle) that, to achieve preselected or predetermined pressure drops as a function of flow through the system, adjusts to particular positions as a function of fire fighting fluid pressure differentials. The adjusted position reflects or is an indication of flow through the conduit.

The first adjusting element adjusts in concert a variable foam concentrate orifice. The foam concentrate orifice meters foam into the fire fighting fluid, thus correlating the foam flow to the fire fighting fluid flow rate. As mentioned above, the first adjusting element is typically a baffle or a piston or some obstruction in a conduit, tending to open and close against a fixed seat or seal and thereby to vary a fire fighting fluid orifice in the conduit. It should be recognized that the adjusting element could be any suitable adjusting element. A bearing head, for instance, as in Figure 3A, could vary. The foam concentrate, whose source could be at ambient pressure or at the pressure of the fire fighting fluid, as is known with a bladder pressurization system, or at greater or lower pressures, is introduced into the fire fighting fluid proximate a reduced pressure region. Typically this is the low pressure region created by the adjusting element and the variable orifice. A reduced pressure region enhances the flow of the foam concentrate into the fire fighting fluid (and in addition the foam concentrate could be a thixotropic fluid) and can assist to a greater or lesser extent in the drawing in, or in the pumping in, of the foam concentrate.

The position of the first adjusting element, or the size of a varying fire fighting fluid orifice, is indicative of fire fighting fluid flow rate through the conduit. The adjustment of the first element affects the adjustment of a second element, in tandem or in concert, as precalculated or pre-calibrated. The second adjusting element varies an orifice through which the foam concentrate passes in the process of being discharged into the fire fighting fluid stream. The first and second adjusting elements accordingly adjust such that, for at least a portion of the anticipated fire fighting fluid flow rates, the greater the fire fighting fluid flow rate, the greater the foam concentrate orifice opening. It might be true that, to some extent, the greater the fire fighting fluid flow rate, the greater the pressure drop created for the fire fighting fluid in the conduit. However, preferred embodiments of the instant invention target maintaining a relatively constant and not too high pressure drop, for purposes of efficiency.

Both the foam concentrate orifice size and the pressure drop proximate the discharge of the foam concentrate into the fire fighting fluid affect the metering of the foam concentrate into the fire fighting fluid. In cases with a built-in eductor, as in Figure 3A, foam concentrate might be discharged into a first portion of the fire fighting fluid, at a first pressure drop region, and then subsequently into the remainder of the fire fighting fluid, proximate a second pressure drop region.

Figure 3A illustrates one embodiment of a metering device or valve for proportioning a foam concentrate into a fire fighting fluid conduit having variable flow rates. In the embodiment of Figure 3A, bafflehead BH adjusts to maintain a given pressure drop across the discharge end of nozzle N. The fire fighting fluid flows at such a rate as the fluid source, head pressure, friction drop in the line, and nozzle design (to list key factors) can sustain at the targeted pressure drop. Foam concentrate FC is supplied to the nozzle through inlet 90, pressured at ambient pressure. The adjustment of foam metering tube 96 attached to bafflehead BH, as bafflehead BH adjusts to maintain a constant pressure drop across the bafflehead, adjusts the size of foam concentrate orifice 94. Foam concentrate is drawn into the nozzle by a low pressure region created by the venturi tube of eductor E wherein a portion of fire fighting fluid W is directed through tube J and thence into a larger chamber defined by larger tube 28. Foam concentrate is also drawn in by virtue of a further low pressure area at the discharge end of the nozzle, proximate the downstream end of the bafflehead, opposite and outside of flood plate M. The variance of the size of orifice 94, is calibrated to be adjusted in tandem or in concert with the fluid discharge orifice, by coordinating the movement of the foam metering tube 94 with the movement of bafflehead BH, and provides metering.

The embodiments of Figures 10A and 10B illustrate an application of the metering device of Figure 3A in a conduit C separated from a nozzle discharge outlet or outlets. (In Figure 10A flow is to the left. In Figure 10B flow is to the right.) The flow rate of water W (again, the usual fire fighting fluid) through conduit C will be established by the nature of the fire fighting fluid source, head pressure, availability of fluid, friction loss and number and type of open discharge devices downstream, to list more significant considerations. Foam concentrate FC may be supplied via inlet FCI to conduit C, typically pressurized at a pressure similar to the fire fighting fluid. Pilot relief valve CP can be adjusted to maintain preselected or predetermined pressure drops across bafflehead BH. The pressure drop might be selected to be close to, or center around, 15 psi or 20 psi if foam concentrate FC were supplied at the same general pressure as the fire fighting fluid. An eductor may be utilized or dispensed with Figures 11A, 11B and 11C do not utilize an eductor in the conduit, but they could be redesigned with small adjustments to do so. Figures 10A and 10B are shown utilizing an eductor E. As discussed above, bafflehead BH will close against seat or seal PS until the selected pressure differential across the bafflehead BH in flowing conduit C is maintained. As in the embodiment of Figure 3A, adjustment of bafflehead BH to accommodate greater flow, while maintaining preselected pressure differentials, adjusts baffle stem BS, or flow metering tube 96, which adjusts variable metering orifice VMO, or orifice 94. Adjustment of orifice VMO or 94 adjusts the amount of foam concentrate passing through tube FCIT or tube 96 in conduit C and then into the fire fighting fluid stream proximate a low pressure region LPR downstream of bafflehead BH. A flood plate M may be maintained, as in Figure 10B, or not, as in Figure 10A.

Pilot valve CP in Figure 10B is shown operating in accordance with the same principles and structure as the pilot relief assembly of Figure 3A. The pilot valve setting would likely be calibrated to adjust around a lower differential pressure, say 15 psi or 20 psi at at least low flow rate ranges, to be maintained around bafflehead BH. The details of pilot valve CP in Figure 10A are not indicated, but the valve could utilize and follow designs previously indicated.

A pilot valve CP residing in bafflehead BH, together with the use of balanced pressure across a piston, does not represent the only means for adjusting bafflehead BH in conduit C to effect a pressure drop at adjusted locations in the conduit. The direct use of springs or other biasing means opposing the movement of a bafflehead or a piston in a conduit C could be used. A pilot valve may offer greater accuracy, however, along with reliability, which may compensate for its greater complexity.

Figures 11A, 11B and 11C present an alternative embodiment to the embodiment of Figures 3A, 10A and 10B. The embodiment of Figures 11A, 11B and 11C is particularly applicable to fixed system conduits where a larger pilot valve can be safely attached external to a conduit. (Figure 11C)

The pilot valve CP, as schematically illustrated in Figure 11C, has three positions. A chamber of pilot valve CP is divided by diaphragm CPD and represents a balanced pressure chamber. Chamber port N4 communicates with fire fighting fluid pressure upstream of water flow control piston WFCP through Port PU. Pilot valve chamber port N5 communicates with fire fighting fluid pressure downstream of piston WFCP at port PD. Spring SP in the pilot valve determines and maintains a pressure differential across piston WFCP, at least for a portion of fire fighting fluid flow ranges of the conduit C. When downstream pressure plus the spring pressure balances the upstream pressure, diaphragm CPD will remain in the neutral position, as illustrated in Figure 11C (Note: although Figure 11C indicates the conduit is closed, the neutral position of the pilot valve could hold the piston in any partially open position). Piston WFCP will remain fixed in its position since the liquid in piston chamber CPC is trapped. No vent is provided for the liquid to exit piston chamber CPC, as through port N3, by virtue of seals CPS, when the balanced pressure pilot valve is in the neutral position. (A vacuum, resulting from the absence of a vent to chamber CPC when the pilot valve is in the neutral position, would resist the expansion of chamber CPC.)

During operation, when piston FWCP is open, as per Figure 11B, flow is presumed through conduit C sufficient to satisfy the pressure drop created between downstream discharge device(s) and upstream sources of pressurized fire fighting fluid, taking into account pressure losses created by friction and other causes. (The metering or proportioning device itself will be the source of some pressure loss. However, conduit C is preferably designed to limit the friction loss it causes, and the pressure differential selected by pilot valve spring SP is preferably selected, to the extent possible, to minimize pressure losses caused by the metering device as a whole, and thus to maximize the efficiency of the metering device.) Unlike other metering devices, the pressure drop across the baffle or piston of the preferred embodiment of the instant invention need not vary significantly with the fire fighting fluid flow rate through the conduit.

In Figure 11C the piston WFPC, closing or squeezing towards water inlet WI and limiting the size of variable water outlet VWO, creates a heightened pressure upstream of piston WFPC. Given an established required flow rate, by the dynamics of the system, if the piston WFPC moved downstream, or to the left, opening variable water outlet VWO further, the pressure drop between the upstream port PU and downstream port PD would diminish below the targeted amount set by pilot valve spring SP. At such point the diaphragm CPD would move to the right, placing the water flow piston chamber CPC into fluid communication with liquid in the conduit upstream of the water flow piston, through ports N1, N3 and PU. Fluid pressure across the water flow piston would be the same. As with the baffle in Figures 3A, 10A and 10B, piston WFCP offers greater pressure area PRA on its back or left or chamber side to the pressure in the chamber CPC (approximately 10% greater area in the embodiment illustrated in Figure 1C) than pressure area PFA offers to the forward pressure on the forward or upstream right side of the piston WFCP. As a result, when pressure within the pressure chamber CPC is balanced with the forward pressure, the piston tends to close, reducing the size of the variable water orifice VWO. As piston WFCP closes, the orifice VWO closes and a greater pressure differential is built up across piston WFCP between port PU and port PD. When the pressure differential between PU and PD again equals the value of pilot spring SP, diaphragm CPD moves to a neutral position . In the neutral position water flow piston chamber CPC becomes closed and piston WFCP stops moving.

If the piston were relocated in the conduit to the right, or moved upstream, creating a narrowed water orifice VWO, small enough that the pressure differential between PU and PD exceeded the pilot spring SP value, diaphragm CPD would move to the left and piston chamber CPC would be put in fluid communication with fluid in the conduit C downstream of the piston, at port PD, through ports N2 and N3. Such pressure would be low enough in piston chamber CPC, even against the greater area PRA of piston WFCP, that the piston would move to the left, opening the water orifice VWO and thereby lowering the pressure drop across the piston.

As piston WFCP adjusts, tube CPS varies the variable metering orifice opening VMO, shown more clearly in Figure 11C as a slot, thereby varying the metering of foam concentrate into the water at a low pressure region LPR.

In operation, if the proportioning device is associated with a conduit in a nozzle as per Figure 3A, then an adjustable bafflehead BH, structured and designed to create a constant discharge pressure at the discharge end of the nozzle, as discussed above, will operate to create a gap between the bafflehead and the nozzle bore, or nozzle bore bearing head. The size of the gap serves to discharge fire fighting fluid at the preselected constant discharge pressure (within the designed operating range of the nozzle, it should be understood). The bafflehead can operate against simple fixed springs or by using a pilot valve for adjusting a pressure balance across a bafflehead surface, as discussed above. The gap forms a variable fire fighting fluid, or water, orifice. The size of the gap or water orifice will vary depending upon fire fighting fluid or water flow. As the bafflehead moves and the gap varies, a baffle stem or flow metering tube is moved in concert with the bafflehead to vary a foam concentrate metering orifice. This orifice, situated in a passageway through which foam concentrate is supplied to the fire fighting fluid, is calibrated to meter a varying amount of foam concentrate into the varying flow of fire fighting fluid. Most likely, a proper calibration will be determined by tests on a nozzle-by-nozzle basis as nozzle size and design varies. A variety of factors affect the metering. The proportioning device of Figure 3A is shown incorporated into a self-educting nozzle, having an eductor E in the nozzle bore or body or conduit. The proportioning device could be operated with or without an eductor.

The metering device or proportioning device of the instant invention may be located or placed in a fire fighting fluid conduit removed from a nozzle discharge orifice. This location or placement is illustrated in Figures 10A and 10B and in Figures 11A, 11B and 11C. The proportioning device has application independently of a nozzle discharge orifice. The adjustable bafflehead or piston of Figure 3A could be located at any location in a fire fighting conduit having variable flow, especially significantly variable flow. In such case, a baffle head or piston or the like operates to create a pressure drop, not in order to define nozzle discharge pressure but in order to create a pressure drop in a flowing fire fighting fluid conduit as an indicator of fire fighting fluid flow rate, and also in preferred embodiments, such that a foam concentrate can be reliably discharged into the fire fighting fluid proximate such pressure drop. As with nozzle discharge gap, the size of the gap or orifice through which the fire fighting fluid passes is an indicator of fire fighting fluid flow rate. That indicator can be tied to an adjustable foam concentrate orifice so that the fluid gap or fluid orifice and foam concentrate orifice adjust in concert or in tandem. The relative adjustments can be calibrated for a given conduit to yield reliable proportioning. The pressure drop created by the baffle or piston in the fire fighting fluid conduit is preferably only large enough to perform its function or functions. Preferably, the pressure drop would not increase unnecessarily since the pressure drop in the conduit adds to the loss of efficiency of the system as a whole.

If the baffle or piston is adjusted by means a pilot valve, Figures 10A and 10B illustrate that the pilot valve may be built into a baffle chamber. Figures 11A, 11B and 11C illustrate an embodiment where the pilot valve is exterior to the conduit. An exterior pilot valve may be larger, and thus more accurate and more accessible than a pilot valve incorporated into the piston itself.

The system can be operated where the foam concentrate is at ambient pressure or at higher pressures. The proportioning system can incorporate an eductor, where some of the fire fighting fluid is utilized to help draw in foam concentrate. However, such self-eduction is not necessary, but an optional design.

While there are shown and described present preferred embodiments of the invention, it is to be distinctly understood that the invention is not limited thereto, but may otherwise variously embodied and practiced within the scope of the following claims.

The foregoing disclosure and description of the invention are illustrative and explanatory thereof, and various changes in the size, shape, and materials, as well as in the details of the illustrated system may be made without departing from the spirit of the invention. The invention is claimed using terminology that depends upon a historic presumptive presentation that recitation of a single element covers one or more, and recitation of two elements covers two or more, and the like.

Figures 11D through 11H illustrate several methods to accomplish "Deluge" and "Foam Control Valve" capabilities of the proportioning device to provide positive shut-off of both the fire fighting liquid and foam concentrate. Bubble tight shut-off is as a result of the inclusion of seals PS for the first adjusting element and FVS for the second adjusting element as shown in the above-mentioned Figures as well as Figure 11A. With the first adjusting element being in concert with the second adjusting element, this allows for desired simultaneous opening of each adjusting element upon implementation of an illustrated or similar control circuit. Figures 11D through 11G illustrate two methods to achieve simple "automatic" mode in which the pilot controls positioning of the first and second adjusting elements and "force close" mode in which pilot operation is bypassed as a function of "Control Valve" port configuration. Figure 11H is an example of how to achieve "automatic" mode in which the pilot controls positioning of the first and second adjusting elements and "full open," "force close" and "alternate control signal" modes in which pilot operation is bypassed as a function of "Control Valve" port configuration. Fire fighting fluid pressure signal from port PU or from "alternate close pressure source" as illustrated in Figure 11H can be utilized to control pressure in CPC and thus positioning of WFCP. As such, the device can be utilized as a "Deluge" and "Foam Control Valve" within a wet or dry type sprinkler or fire suppression system. Not shown but intended for inclusion as referred to in Figure 11A is an integral check valve at FCl to prevent undesired reverse water flow from within conduit C out through foam concentrate inlet FCl.

WHAT IS CLAIMED IS:

1. A system for proportioning foam concentrate into variably flowing fire fighting fluid passing through a conduit, comprising:

a conduit for fire fighting fluid having a variable orifice therein, the variable orifice defined at least in part by a first adjusting element, the element in communication with and structured to adjust at least in part in accordance with pressure differential of fluid in the conduit;

a foam concentrate passageway having a variable concentrate orifice, the concentrate passageway in fluid communication with fluid passing through the conduit, the variable concentrate orifice at least in part defined by a second adjusting element;

the first and second adjusting elements connected so as to adjust in concert and such that fluid pressure differential acting to adjust the first element enlarges both orifices at a pre-calibrated rates.

2. The apparatus of claim 1 wherein the first adjusting element includes a baffle in the conduit.

3. The apparatus of claim 2 wherein the second adjusting element includes a baffle stem in the conduit, the stem connected to the baffle.

4. The apparatus of claim 1 wherein the first adjusting element is structured to adjust the fire fighting fluid orifice to maintain a preselected pressure drop across the orifice.

5. The apparatus of claim 4 wherein the foam concentrate passageway is structured to discharge foam concentrate into the fire fighting fluid proximate the pressure drop.

6. The apparatus of claim 1 wherein the fire fighting fluid conduit includes an inner conduit and the foaming concentrate orifice includes a variable slot in fluid communication with the inner conduit.

7. The apparatus of claim 6 wherein the inner conduit is structured and located such that a portion of fire fighting fluid passes through the inner conduit.

8. The apparatus in claim 1 wherein the foaming concentrate passageway is in fluid communication with a source of foaming concentrate.

9. The apparatus of claim 8 wherein the source of foaming concentrate is pressurized over atmospheric.

10. The apparatus of claim 8 wherein the source of foaming concentrate is at ambient pressure.

11. The apparatus of claim 1 wherein the fire fighting fluid variable orifice comprises a nozzle orifice.

12. A method for proportioning foaming concentrate into variably flowing fire fighting fluid passing through a conduit, comprising:

adjusting a fire fighting fluid orifice in a fire fighting fluid conduit to maintain a predetermined pressure drop across the orifice as fluid flow rate through the conduit varies;

varying a foam concentrate orifice in concert with the adjustment of the fire fighting fluid orifice; and

supplying foam concentrate through the concentrate orifice into the fire fighting fluid proximate a pressure drop such that a ratio of foaming concentrate proportioned into the fire fighting fluid flowing through the conduit remains approximately constant.

13. The method of claim 12 wherein the predetermined pressure drop varies by less than 100% over designed effective fire fighting fluid flow rates through the conduit.

14. A method for automatically proportioning foam into variably flowing fire fighting fluid, comprising:

varying a fire fighting fluid orifice in a conduit, thereby creating a pressure drop in the conduit and wherein the varying fire fighting fluid orifice acts as a fire fighting fluid flow rate indicator;

varying a foam concentrate orifice, at a rate calibrated in concert with variations of the fire fighting fluid orifice; and

discharging foam concentrate through the variable foam concentrate orifice proximate a low pressure zone created by a pressure drop.

15. The method of claim 14 that includes varying the fire fighting fluid orifice based upon a spring resisting fire fighting fluid pressure in the conduit.

16. The method of claim 14 wherein varying the fire fighting fluid orifice includes setting a pilot valve to maintain one or more pre-selected pressure drops across the orifice.

17. The method of claim 16 wherein the pilot valve is biased by spring.

18. The method of claim 14 wherein varying a fire fighting fluid orifice includes adjusting the lateral movement of a baffle/piston within the conduit.

19. Apparatus, comprising:

an automatic pressure regulating self-educting foam/fog nozzle including an automatically varying foam proportioning orifice.

20. A method comprising:

automatically adjusting a fire fighting nozzle to control discharge pressure;

self-educting foam concentrate into the nozzle using a portion of a fire fighting fluid flowing through the nozzle; and

automatically varying a foam proportioning orifice in order to meter foam concentrate self-educted into the nozzle in accordance with fire fighting fluid flow rate through the nozzle.

21. Proportioning apparatus for fire fighting systems, comprising:

a housing having an adjustable water passageway adapted to be connected to a source of pressurized water and creating a pressure drop;

an adjustable foam concentrate passageway adapted to be connected to a source of foam concentrate and communicating with water from the passageway proximate a pressure drop;

the foam passageway connected to the water passageway to adjust in concert; and

a pilot valve in fluid communication with water pressure upstream and downstream of the adjustable water passageway, the valve adapted to influence the adjustment of the water passageway toward maintaining pre-selected pressure drop.

22. The apparatus of claim 21 wherein the adjustable water passageway includes a dual acting baffle piston, the baffle piston having a first side in fluid communication with upstream water pressure and the baffle piston having a second side in fluid communication through a pilot valve with, alternately, upstream water pressure and downstream water pressure.

23. The apparatus of claim 22 wherein the dual action baffle piston is structured to present unequal surface areas to pressure in opposing directions.

ABSTRACT

A fire fighting nozzle for extinguishing industrial scale fires including improved automatic pressure regulating features, enhanced educting features including central and peripheral channeling for foam concentrate, and combining with a capacity to throw dry chemical. Improved pressure regulating features include a double acting baffle and preferably a relief valve. Method and apparatus for automatically metering an additive such as foam concentrate into a conduit having a variably flowing fire fighting fluid therethrough, the conduit including a discharge device, proximate or downstream.

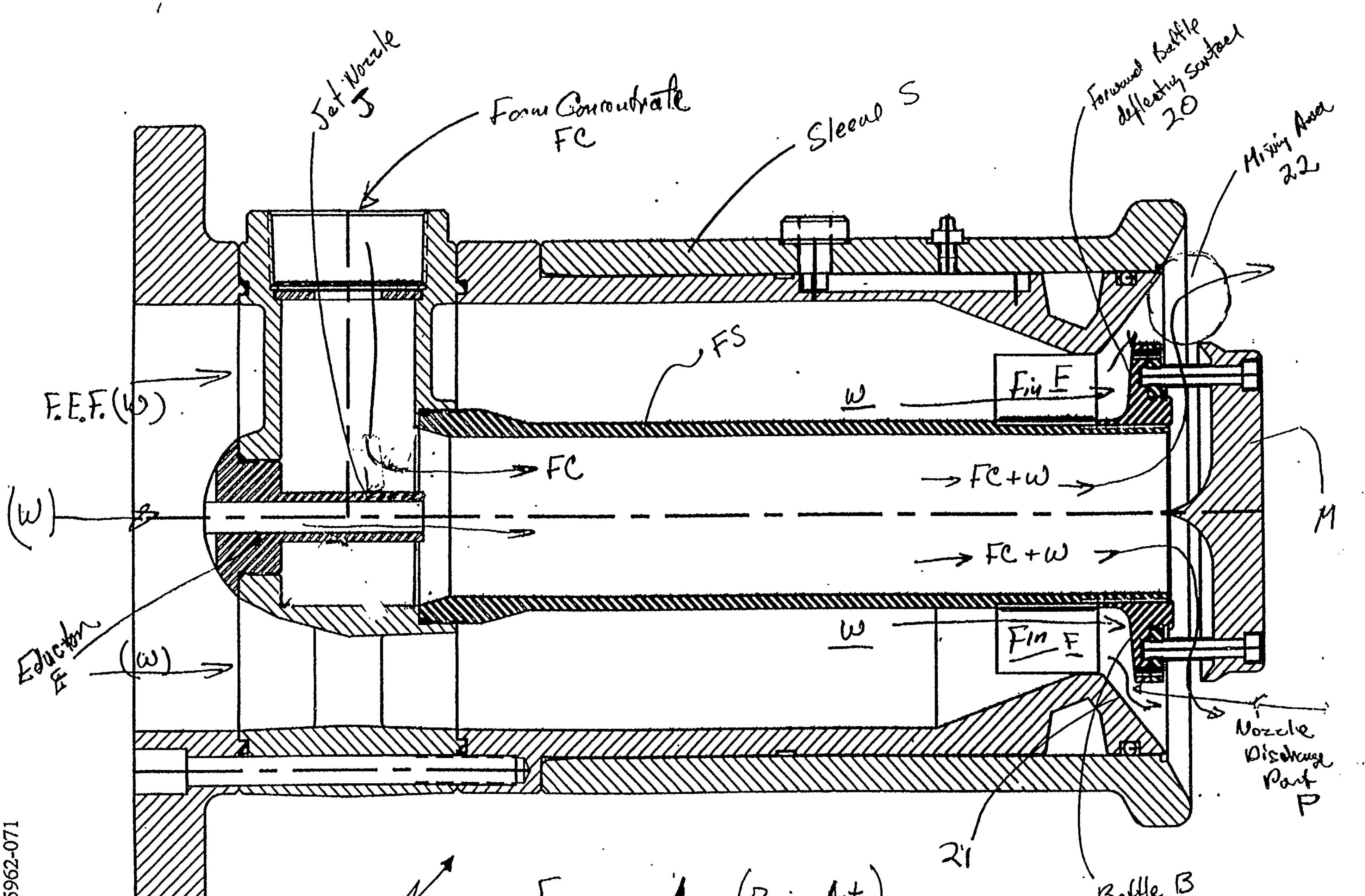


Figure 1 (Prior Art)

Self Educting, Not Self Adjusting

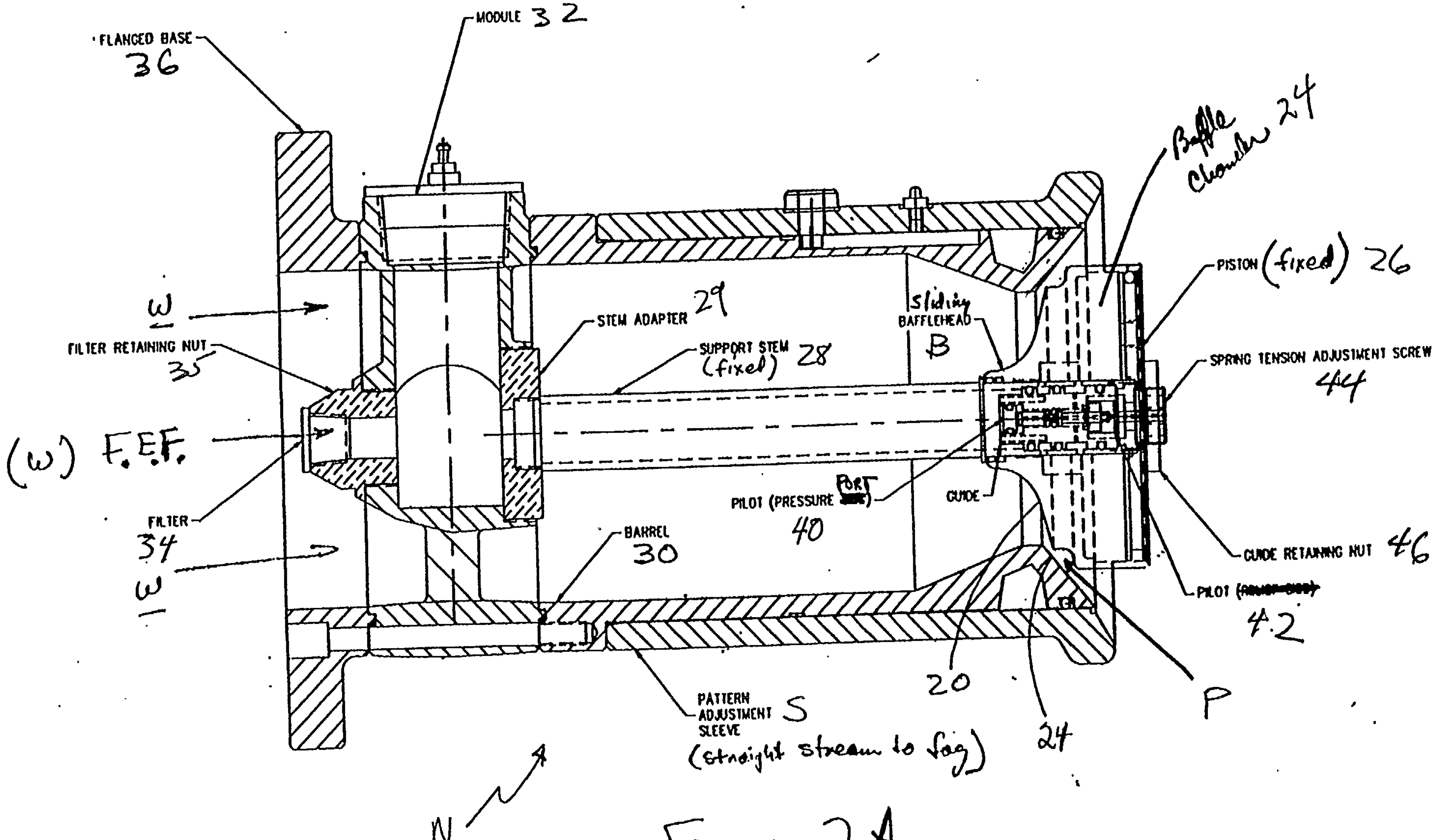


Figure 2A

Self Adjusting Nozzle.

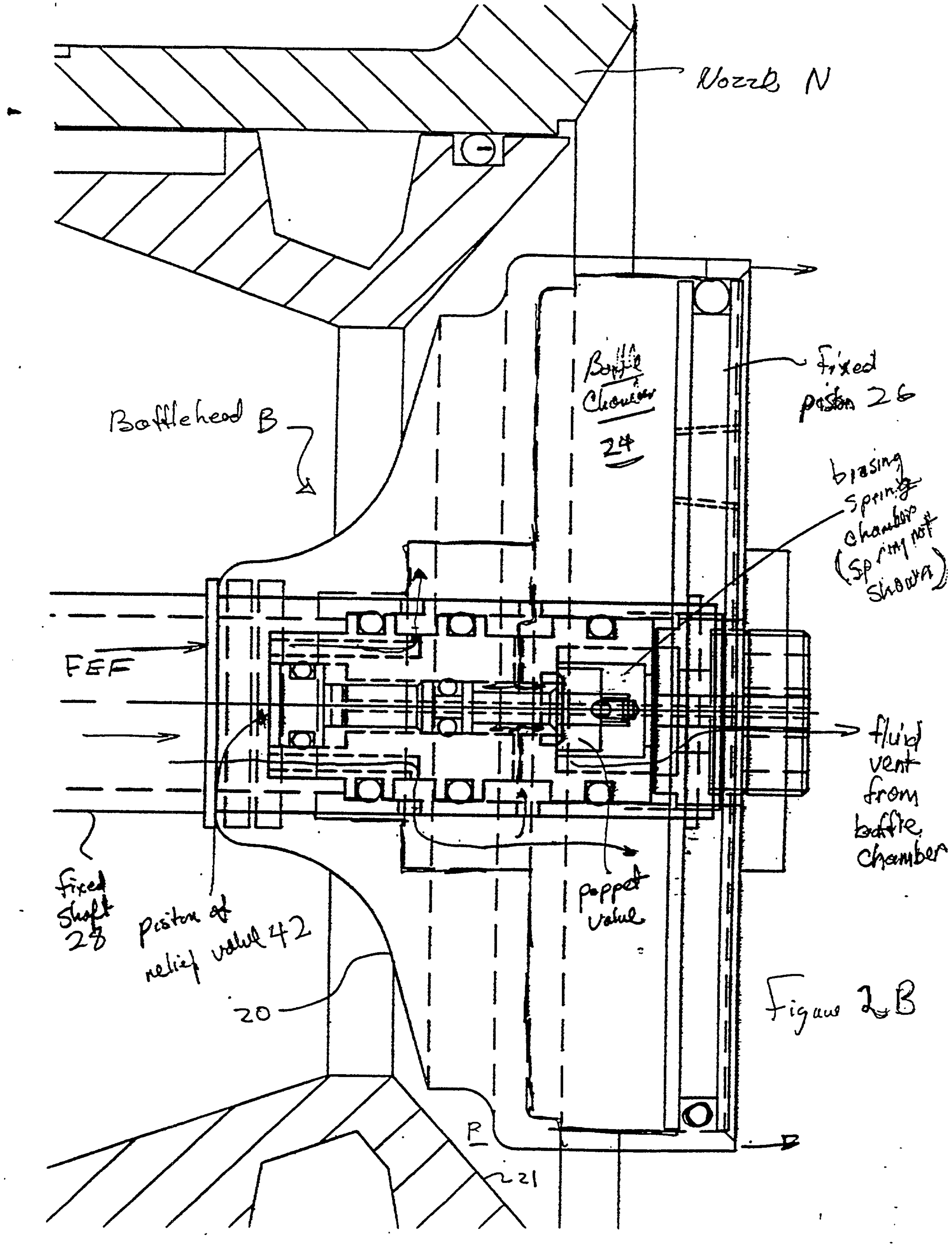
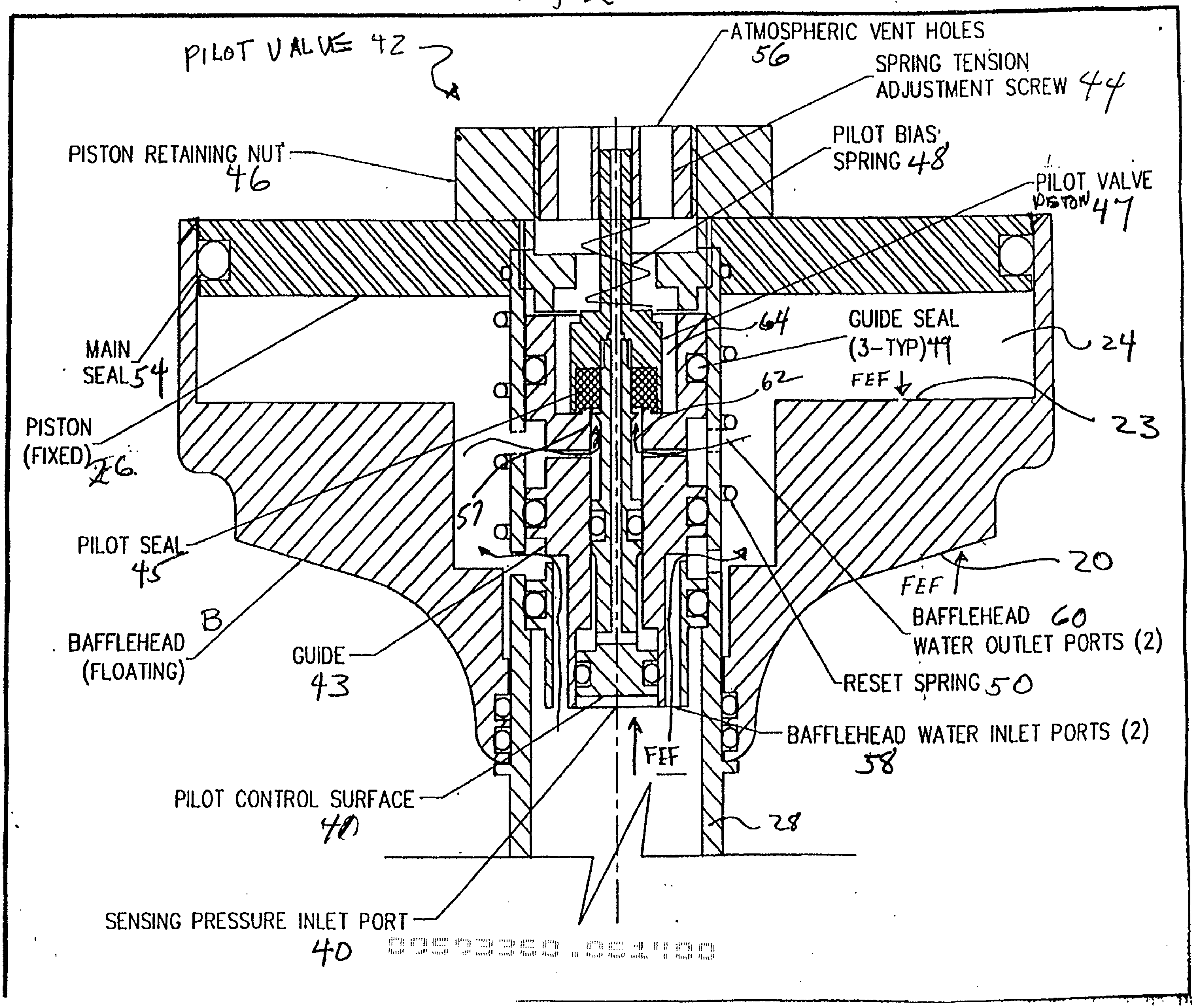

Nozzle N
Baffle Chamber 24
fixed piston 26
Bafflehead B
biasing spring chambers (spring not shown)
FEF
fluid vent from baffle chamber
fixed shaft 28
piston of relief valve 42
poppet valve
20
R
21

Figure 2B

Fig 2C


PILOT VALVE 42
ATMOSPHERIC VENT HOLES 56
SPRING TENSION ADJUSTMENT SCREW 44
PISTON RETAINING NUT 46
PILOT BIAS SPRING 48
PILOT VALVE PISTON 47
MAIN SEAL 54
64
GUIDE SEAL (3-TYP) 49
24
62
FEF
23
PISTON (FIXED) 26
57
PILOT SEAL 45
20
FEF
B
BAFFLEHEAD 60
WATER OUTLET PORTS (2)
BAFFLEHEAD (FLOATING)
GUIDE 43
RESET SPRING 50
BAFFLEHEAD WATER INLET PORTS (2) 58
FEF
PILOT CONTROL SURFACE 40
28
SENSING PRESSURE INLET PORT 40

AUTOMATIC NOZZLE
WATER ONLY

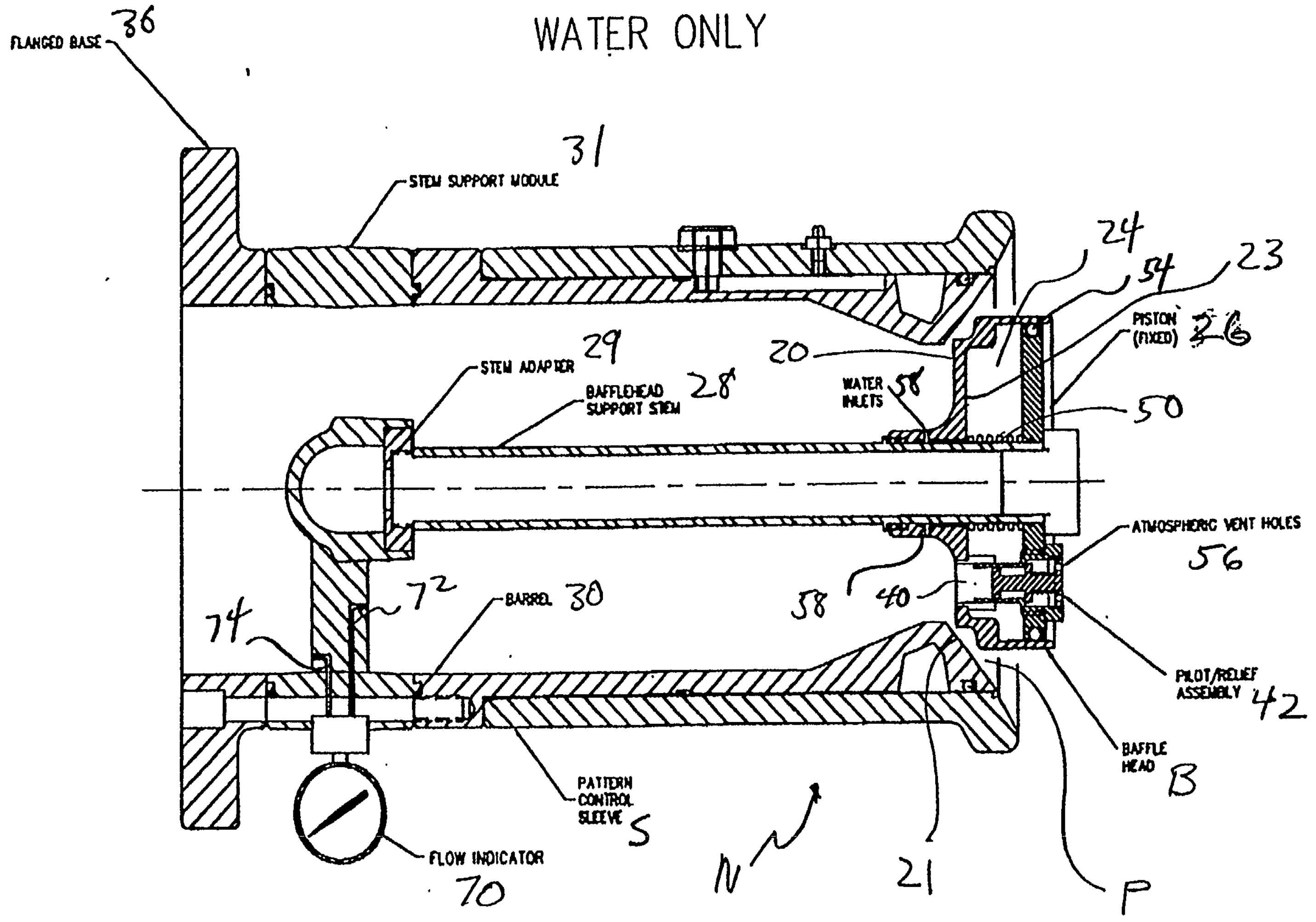
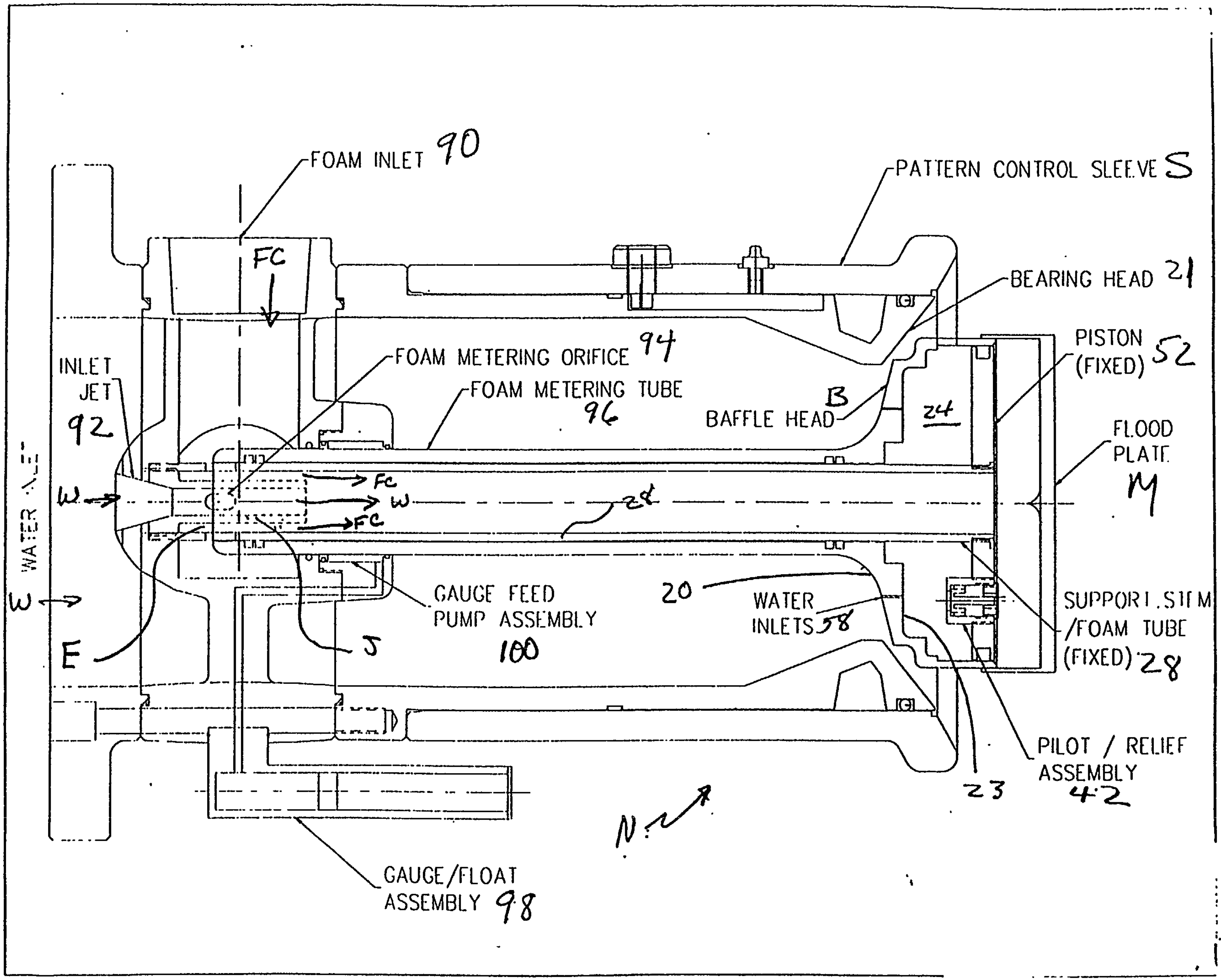


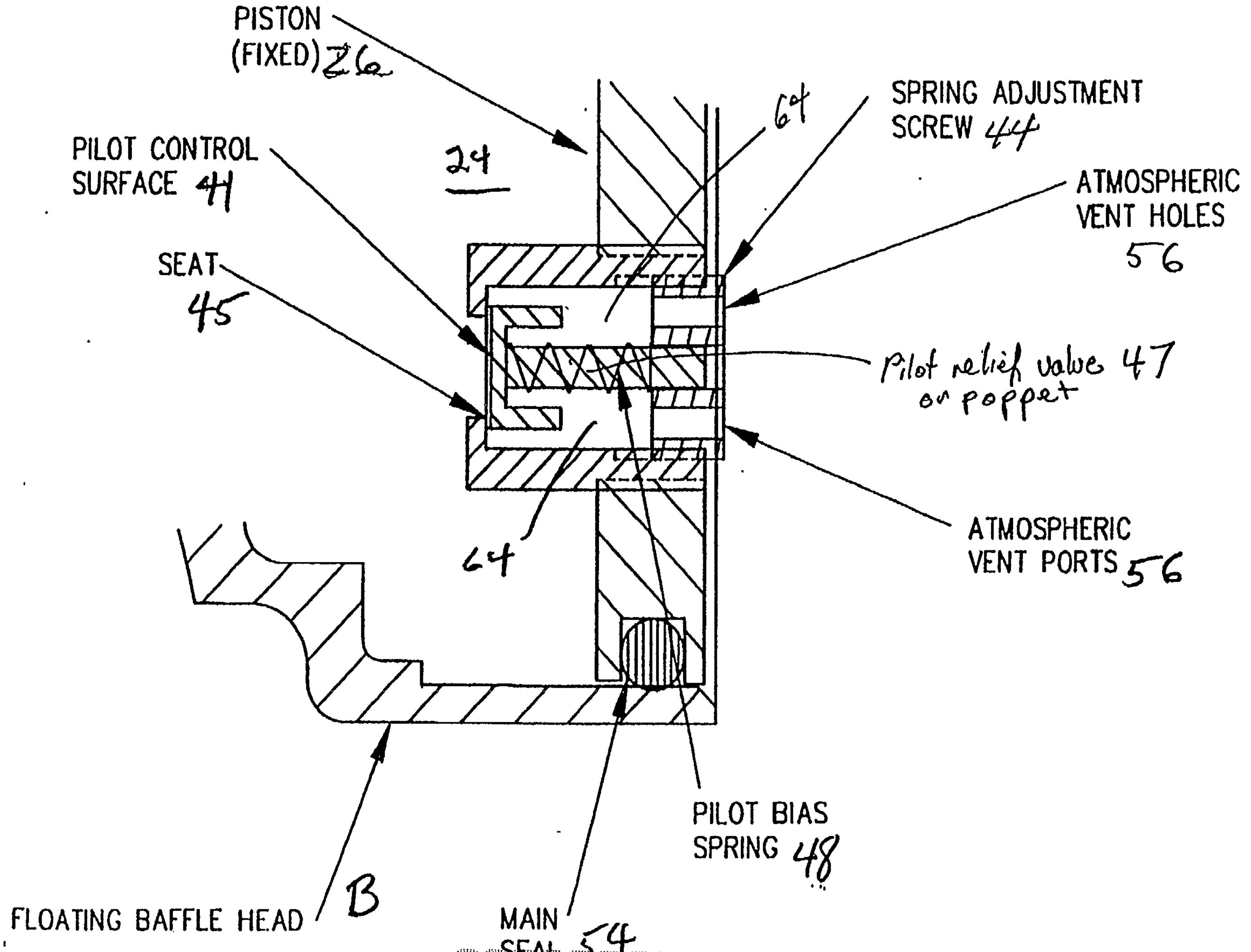
Fig 2D



PREFERRED DESIGN

Figure 3A

Fig 3B


PISTON
(FIXED) 26
24
PILOT CONTROL
SURFACE 41
SEAT
45
64
SPRING ADJUSTMENT
SCREW 44
ATMOSPHERIC
VENT HOLES
56
Pilot relief valve 47
or poppet
ATMOSPHERIC
VENT PORTS 56
64
PILOT BIAS
SPRING 48
FLOATING BAFFLE HEAD
B
MAIN
SEAL 54

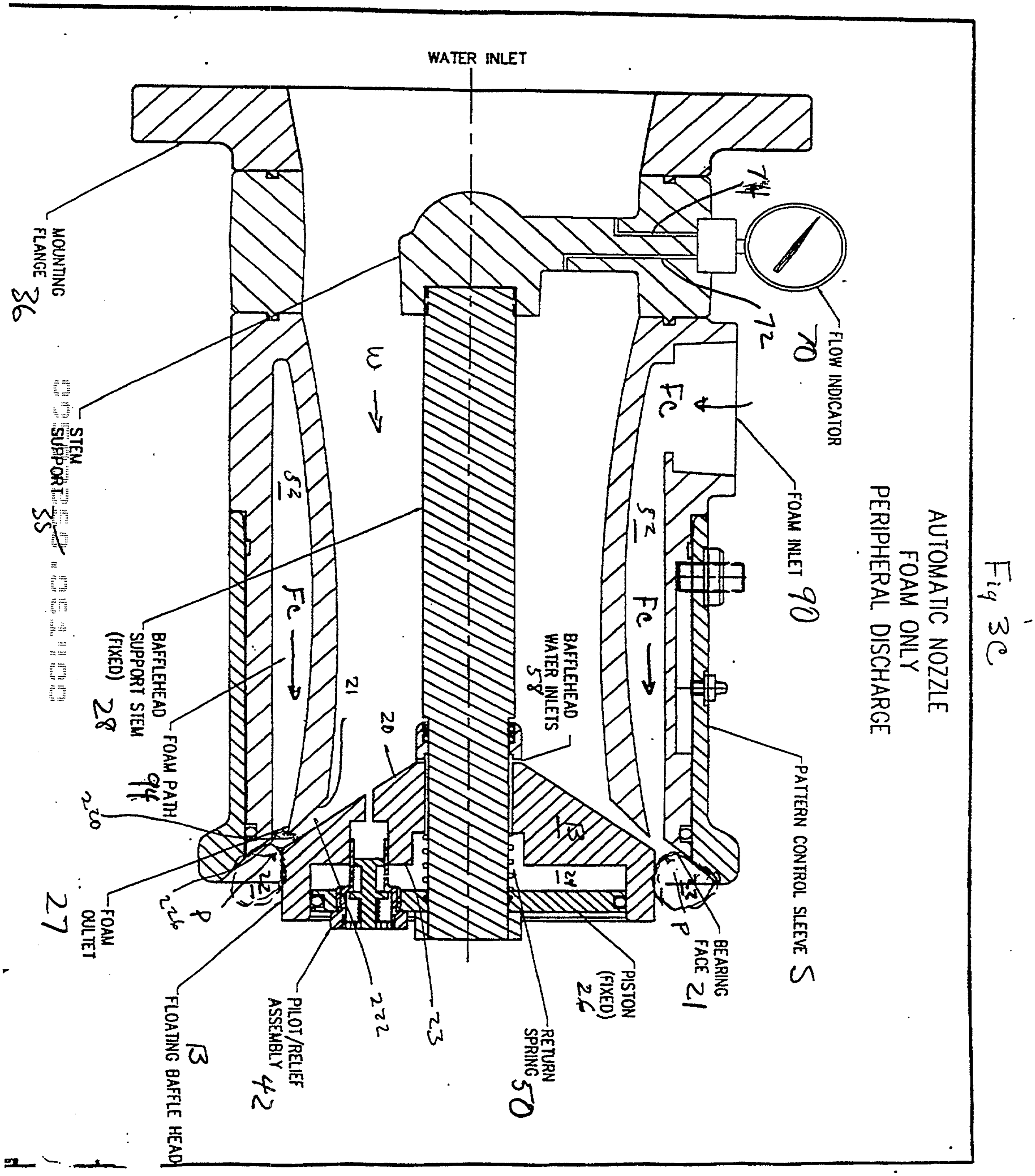
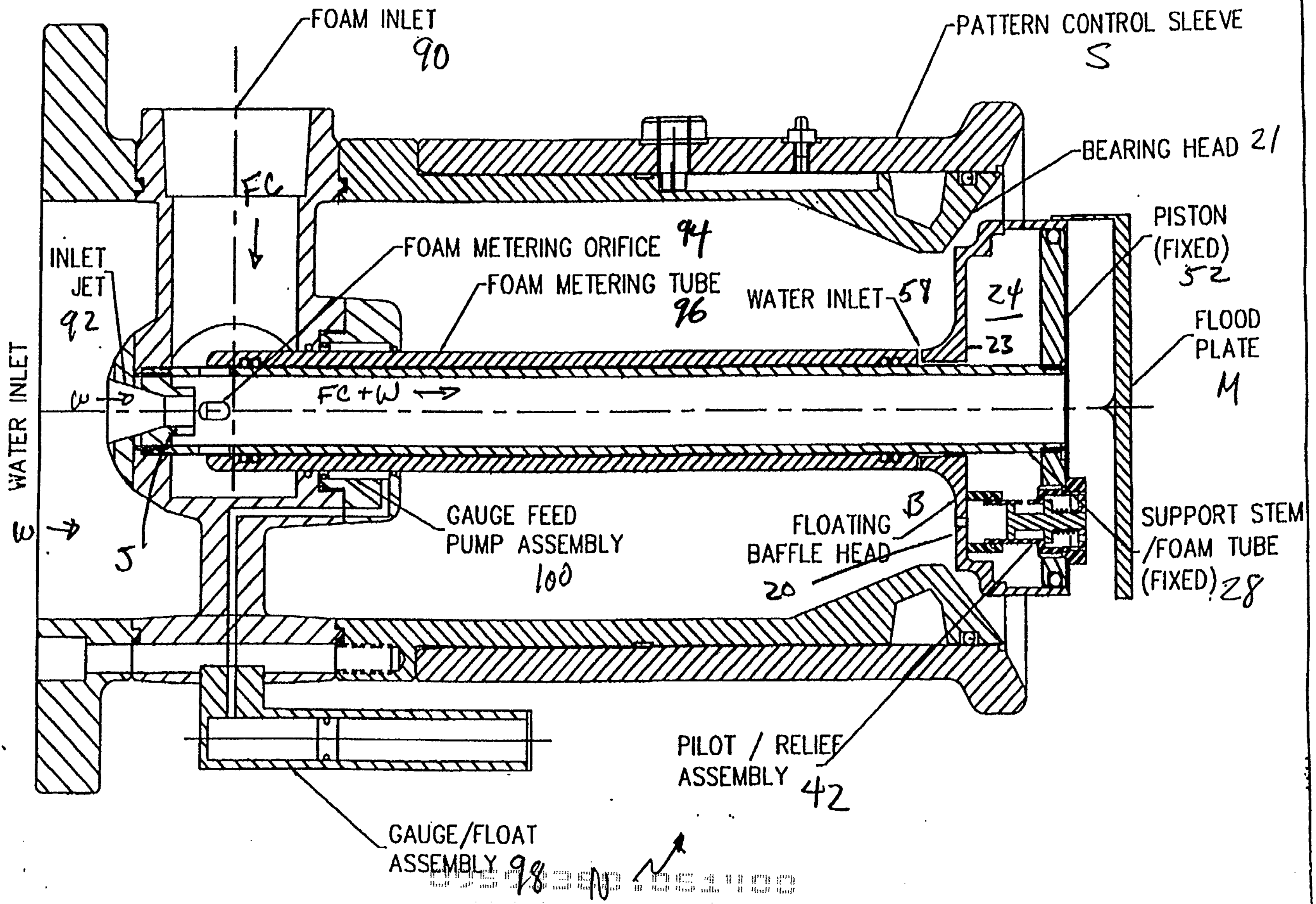


Fig 3c

AUTOMATIC NOZZLE
FOAM ONLY
PERIPHERAL DISCHARGE

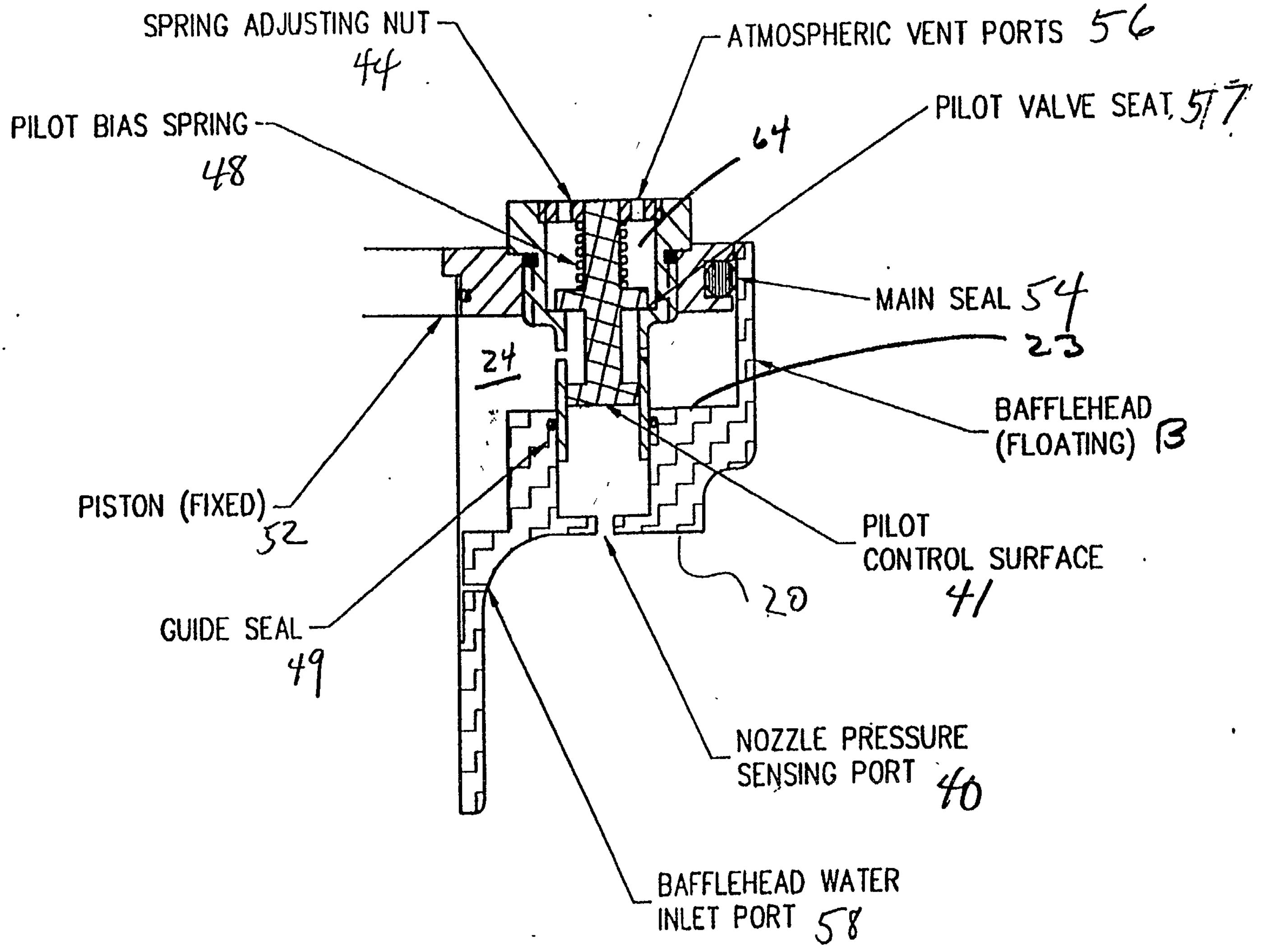
Fig 3.D

AUTOMATIC NOZZLE
FOAM ONLY
CENTRAL DISCHARGE



09529380.064100

Fig. 3E


SPRING ADJUSTING NUT 44
ATMOSPHERIC VENT PORTS 56
PILOT VALVE SEAT 57
PILOT BIAS SPRING 48
64
MAIN SEAL 54
23
24
BAFFLEHEAD (FLOATING) 13
PISTON (FIXED) 52
PILOT CONTROL SURFACE 41
20
GUIDE SEAL 49
NOZZLE PRESSURE SENSING PORT 40
BAFFLEHEAD WATER INLET PORT 58

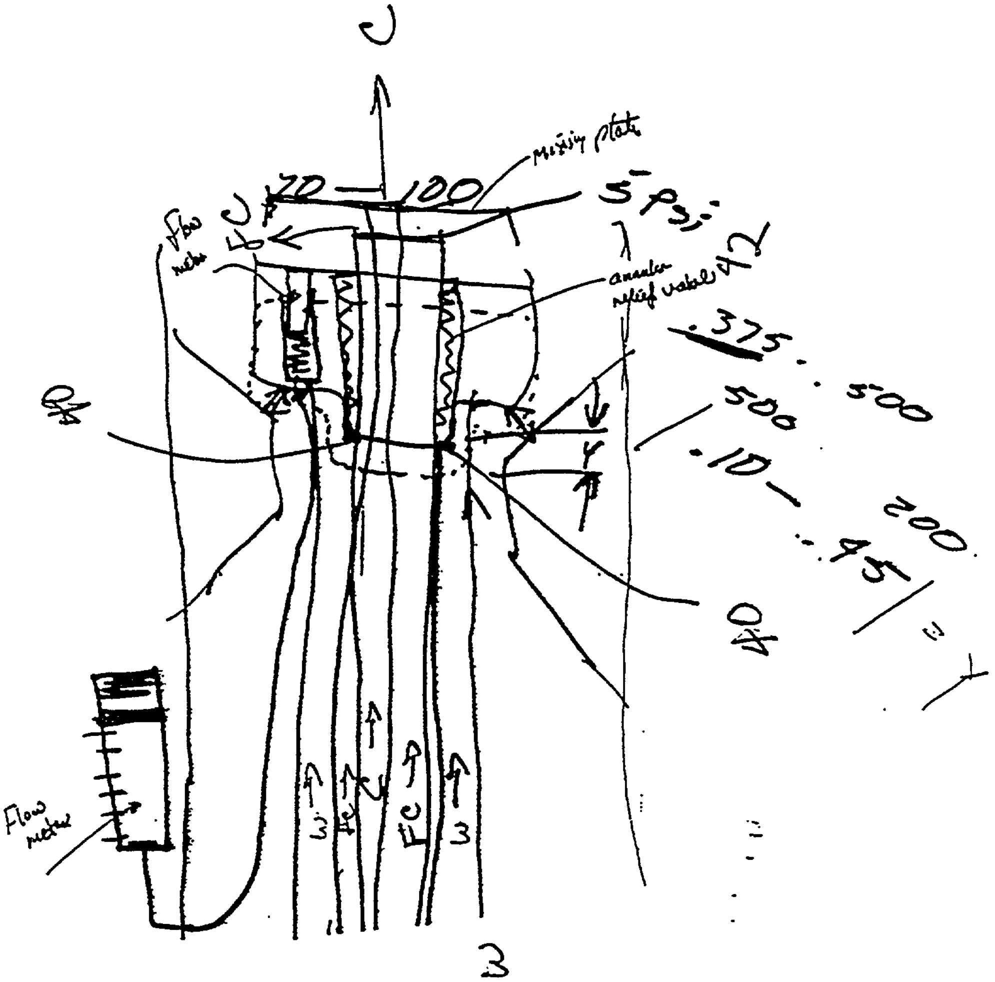

C
20
100
mixing plate
5 psi
flow meter
6
C
annular relief valve 42
.375 . .500
.500
.10 - .200
.45
4
40
40
Flow meter
W
He
FC
3
3

Figure 4A

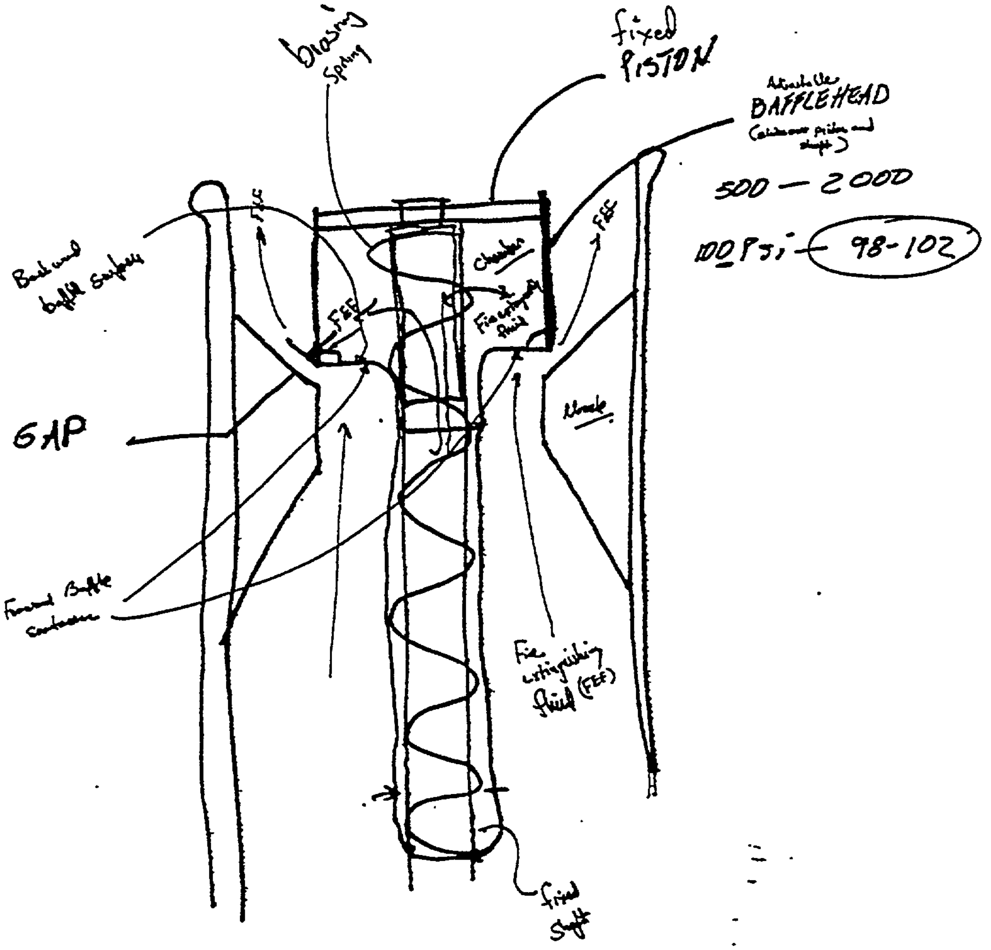
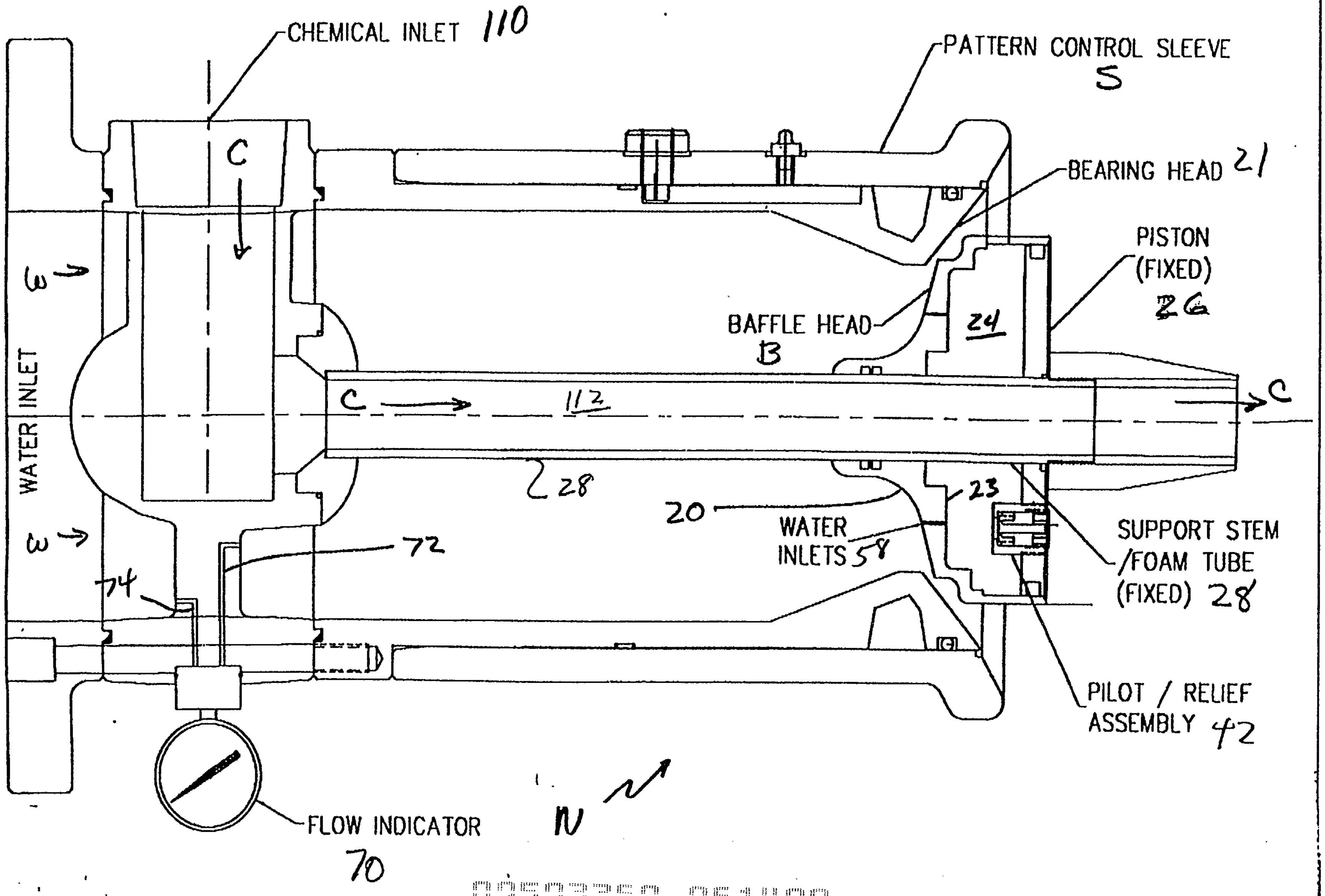

biasing Spring
fixed PISTON
Actuatable BAFFLEHEAD (eliminates piston and shaft)
500 — 2000
100 PSI — 98-102
Back and baffle surfaces
FEE
FEE
FEE
Chamber
Fire extinguishing fluid
GAP
Nozzle
Forward Baffle contours
Fire extinguishing fluid (FEE)
fixed Shaft

Figure 4B

Fig 4C


CHEMICAL INLET 110
PATTERN CONTROL SLEEVE
S
BEARING HEAD 21
PISTON
(FIXED)
26
BAFFLE HEAD
B
24
C
C
112
C
WATER INLET
w
w
74
72
28
20
WATER
INLETS 58
23
SUPPORT STEM
/FOAM TUBE
(FIXED) 28
PILOT / RELIEF
ASSEMBLY 42
FLOW INDICATOR
70
N

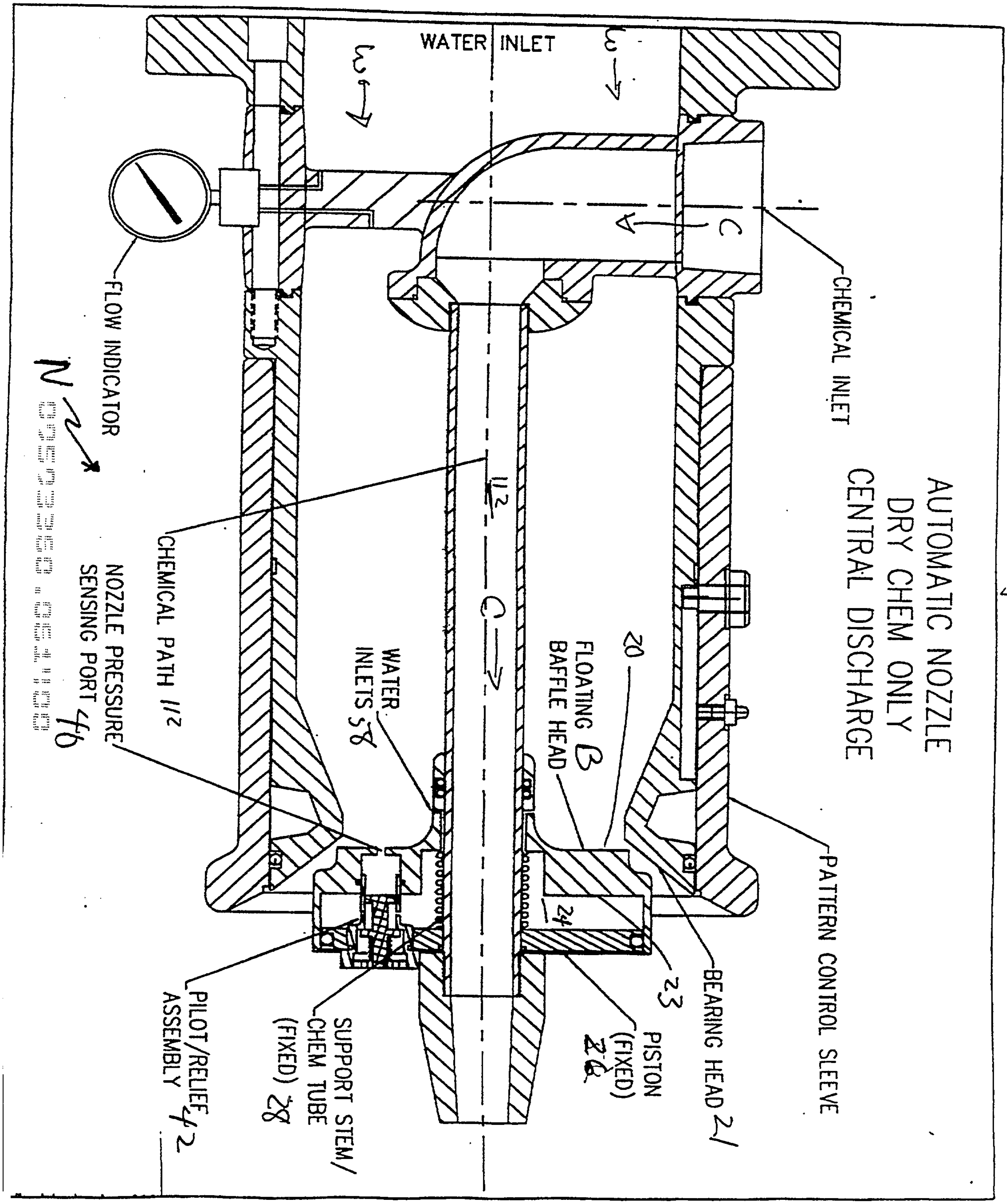


Fig 4 D

AUTOMATIC NOZZLE
DRY CHEM ONLY
CENTRAL DISCHARGE

Fig 5A

AUTOMATIC NOZZLE
FOAM PERIPHERAL
DRY CHEMICAL CENTRAL

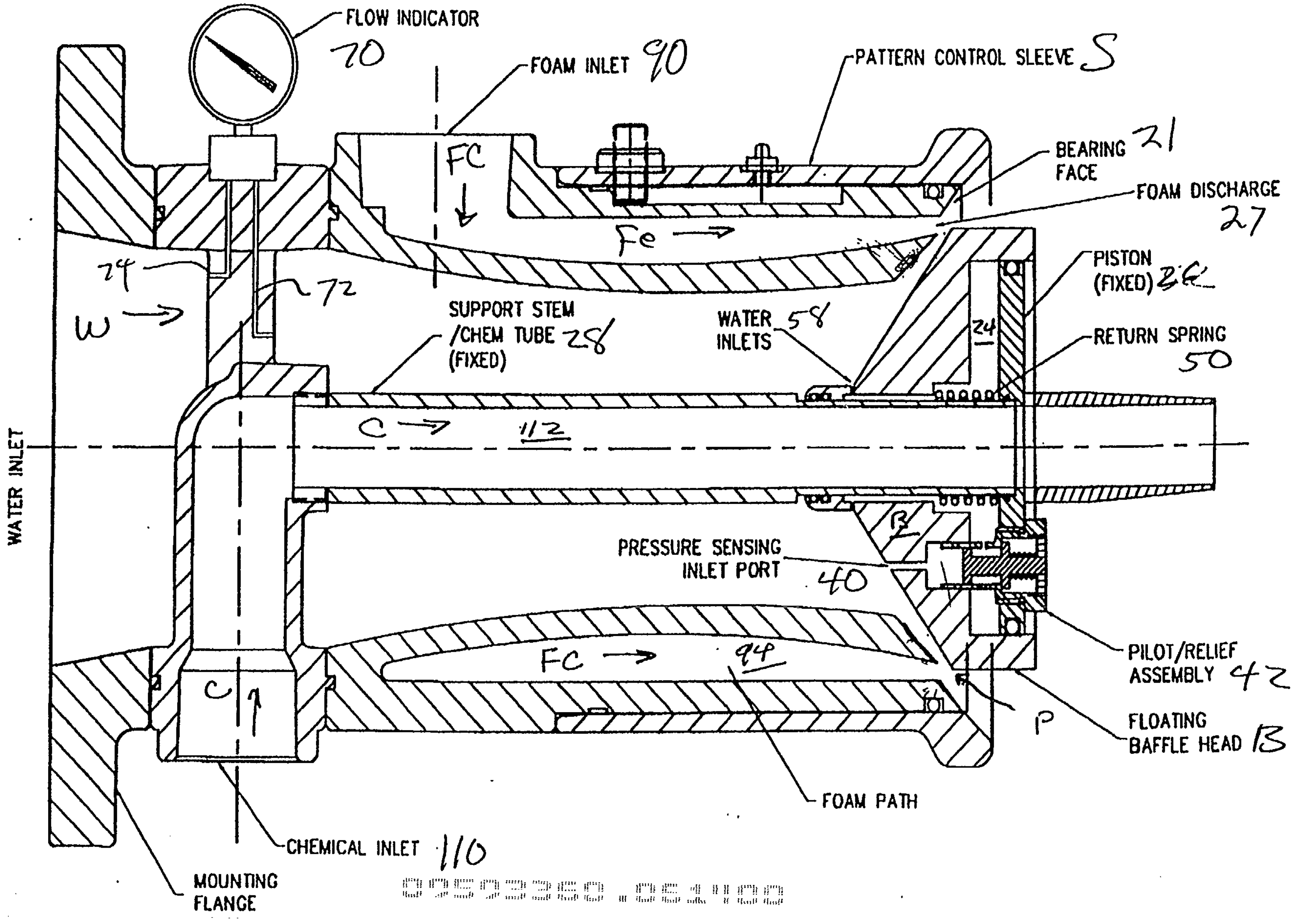


Fig 5.B

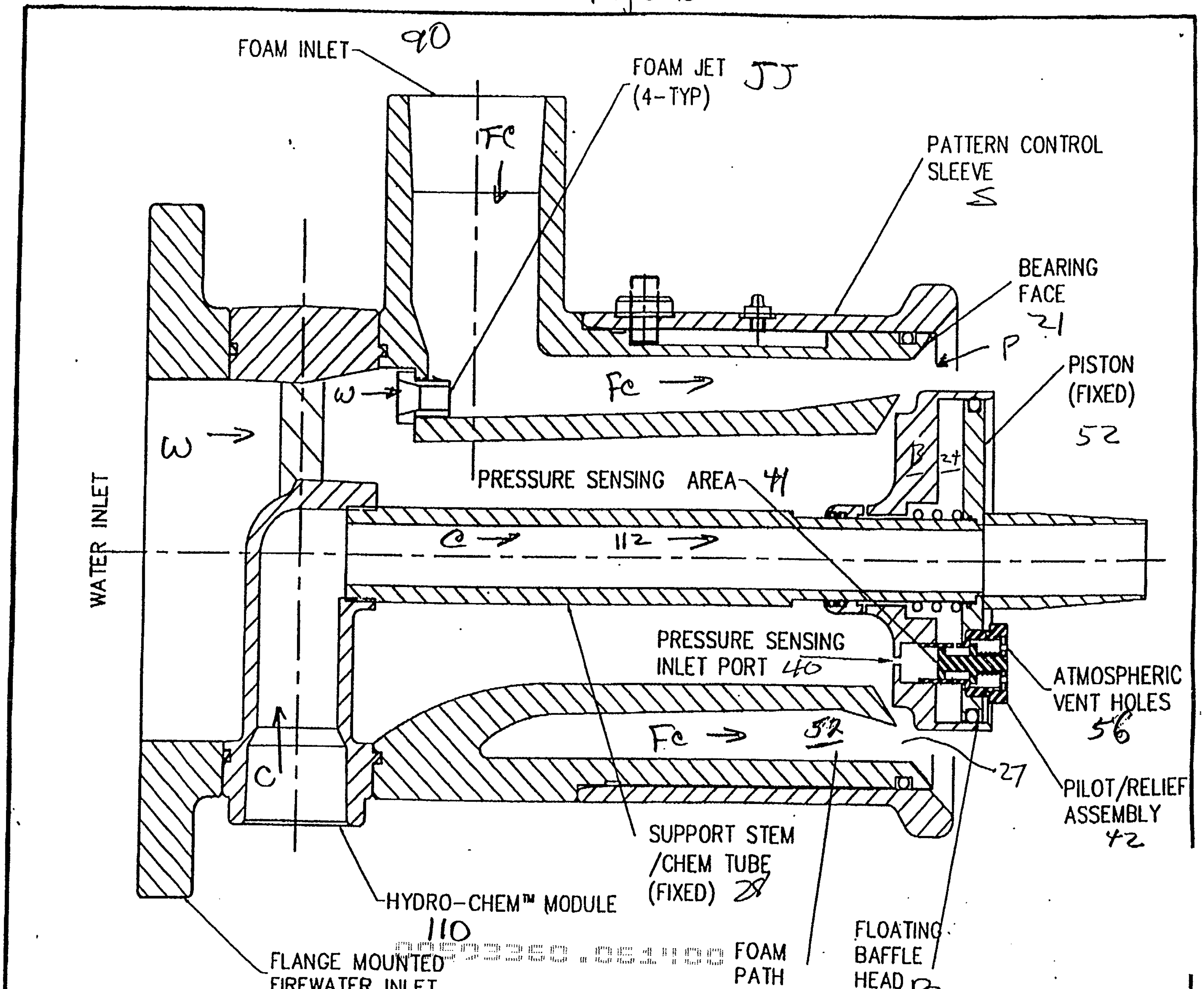

FOAM INLET
90
FOAM JET
(4-TYP)
JJ
FC
PATTERN CONTROL
SLEEVE
S
BEARING
FACE
21
P
PISTON
(FIXED)
52
W
W
Fc
B
24
WATER INLET
PRESSURE SENSING AREA
41
C
112
PRESSURE SENSING
INLET PORT 40
ATMOSPHERIC
VENT HOLES
56
Fc
57
27
PILOT/RELIEF
ASSEMBLY
42
C
SUPPORT STEM
/CHEM TUBE
(FIXED) 28
HYDRO-CHEM™ MODULE
110
FLANGE MOUNTED
FIREWATER INLET
FOAM
PATH
FLOATING
BAFFLE
HEAD B

Fig 5C

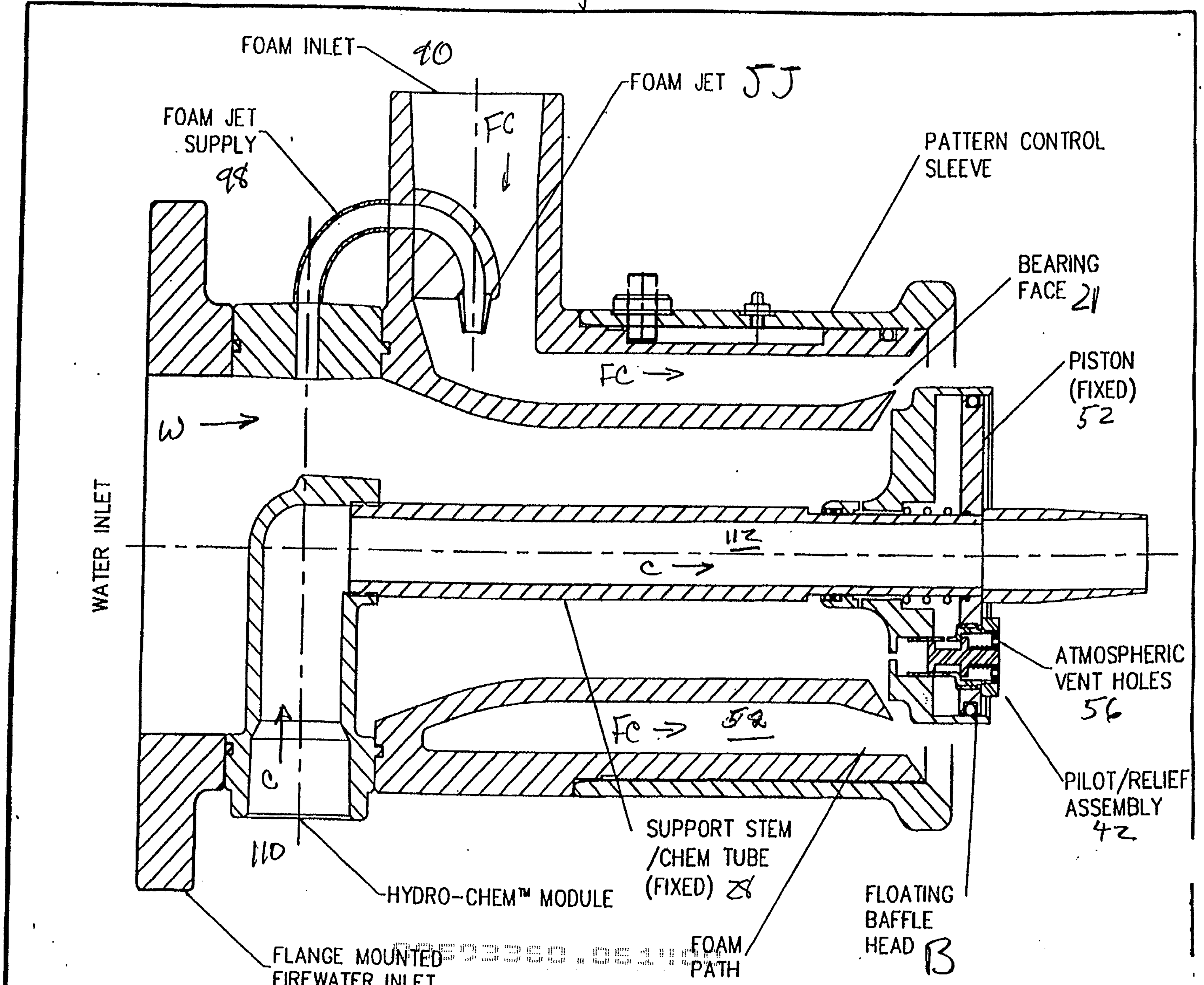
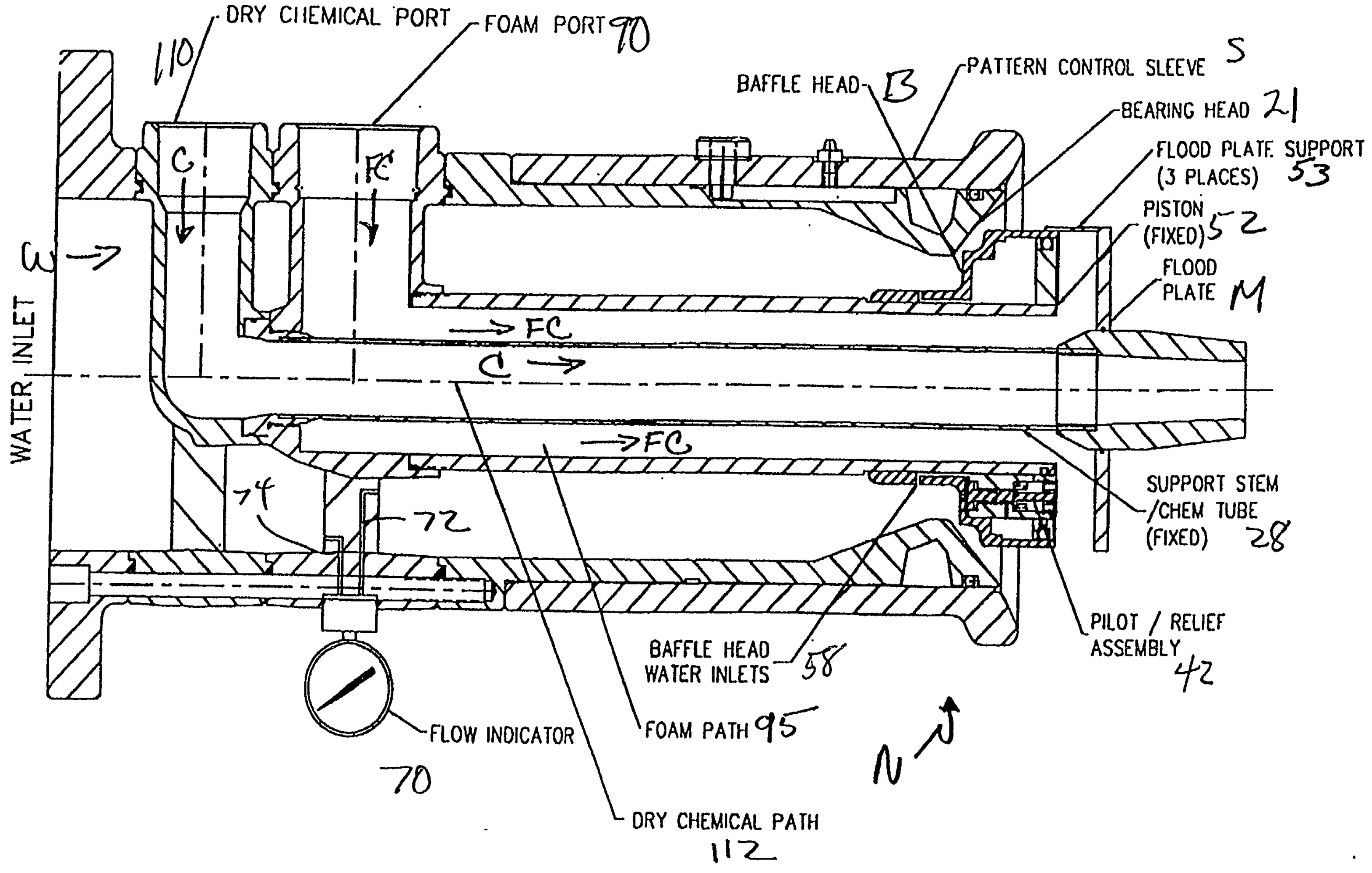

FOAM INLET 10
FOAM JET 5J
FOAM JET SUPPLY 98
FC
PATTERN CONTROL SLEEVE
BEARING FACE 21
PISTON (FIXED) 52
FC →
W →
WATER INLET
112
C →
C
ATMOSPHERIC VENT HOLES 56
FC → 58
PILOT/RELIEF ASSEMBLY 42
110
SUPPORT STEM /CHEM TUBE (FIXED) 28
HYDRO-CHEM™ MODULE
FLOATING BAFFLE HEAD 13
FOAM PATH
FLANGE MOUNTED FIREWATER INLET

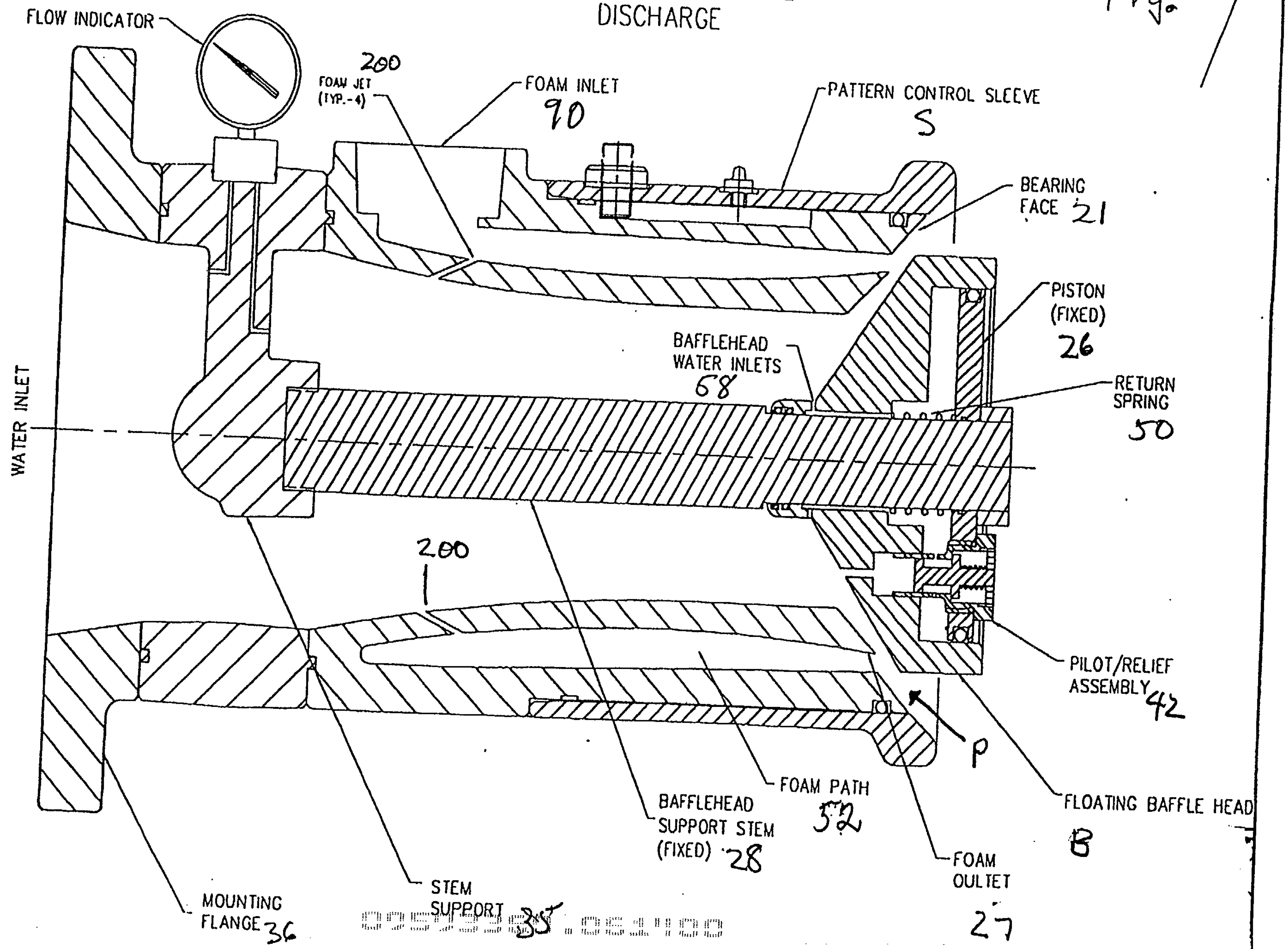
Fig 6

AUTOMATIC NOZZLE
FOAM & DRY CHEMICAL
CENTRAL DISCHARGE



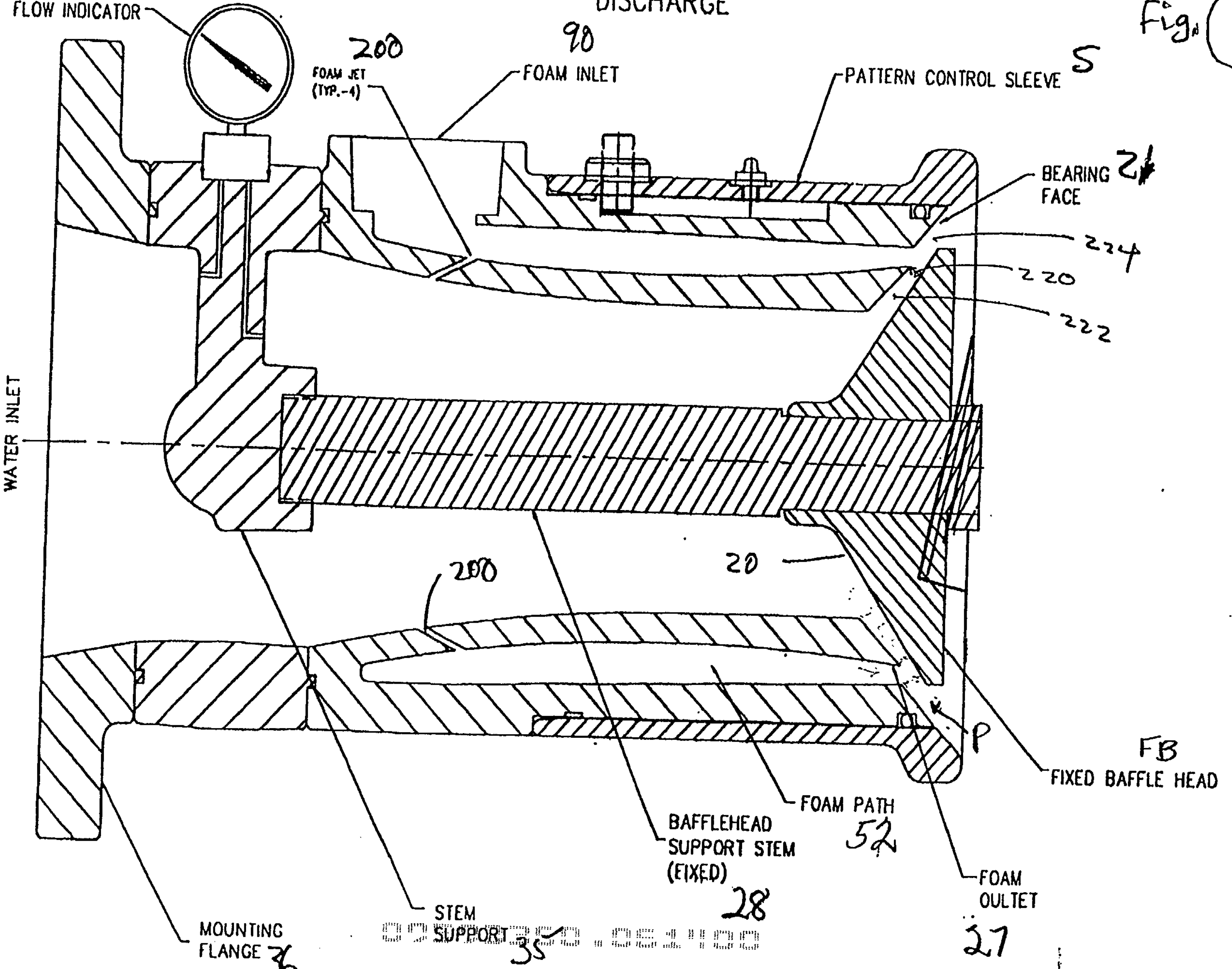
AUTOMATIC NOZZLE
FOAM ONLY
ENHANCED PERIPHERAL
DISCHARGE

Fig. 7



FIXED GALLONAGE NOZZLE
FOAM ONLY
ENHANCED PERIPHERAL
DISCHARGE

Fig. 8



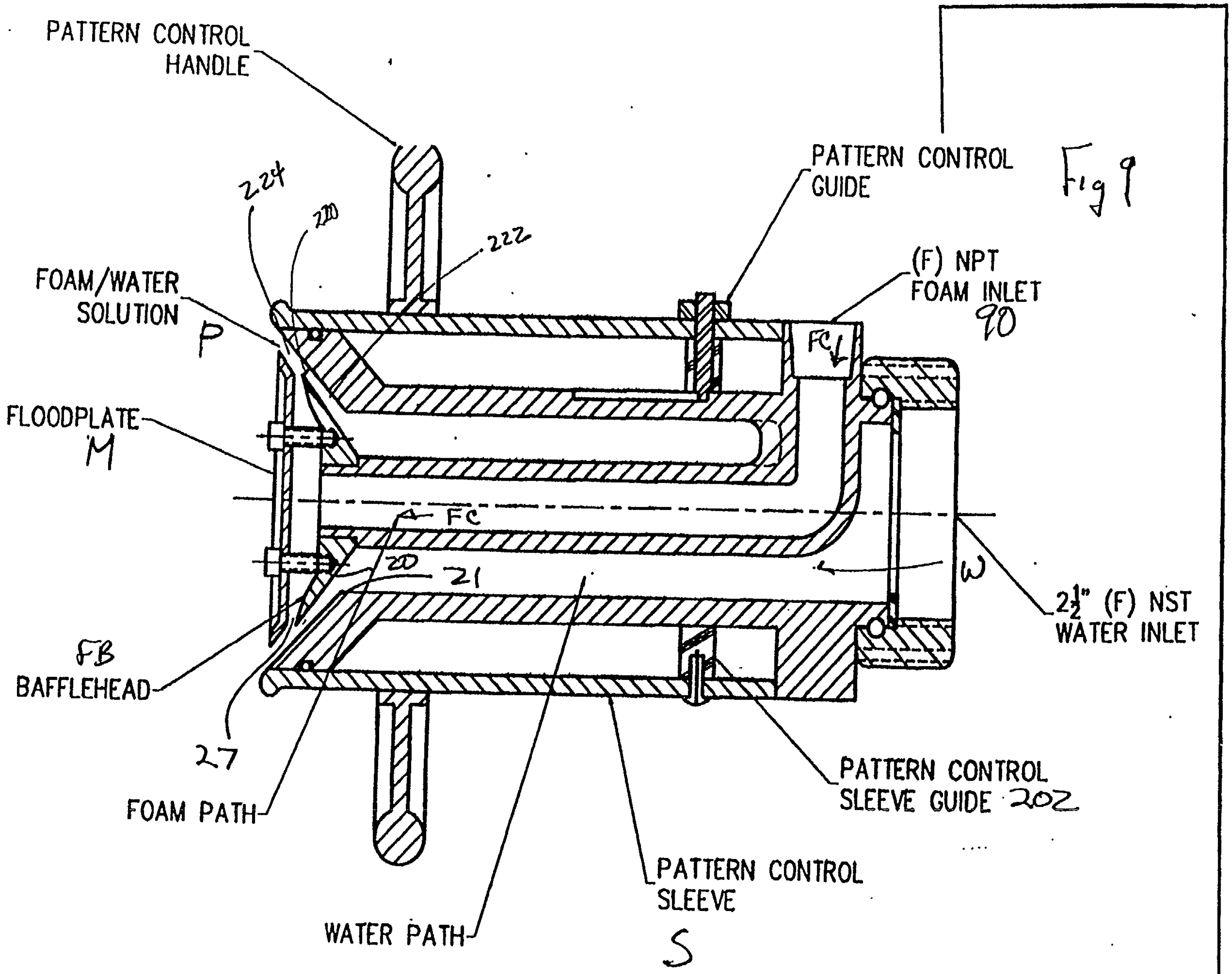

PATTERN CONTROL HANDLE
224
220
222
FOAM/WATER SOLUTION
P
FLOODPLATE
M
FC
20
21
FB
BAFFLEHEAD
27
FOAM PATH
WATER PATH
PATTERN CONTROL SLEEVE
S
PATTERN CONTROL SLEEVE GUIDE 202
PATTERN CONTROL GUIDE
(F) NPT FOAM INLET
90
FC
W
2½" (F) NST WATER INLET

Fig 9

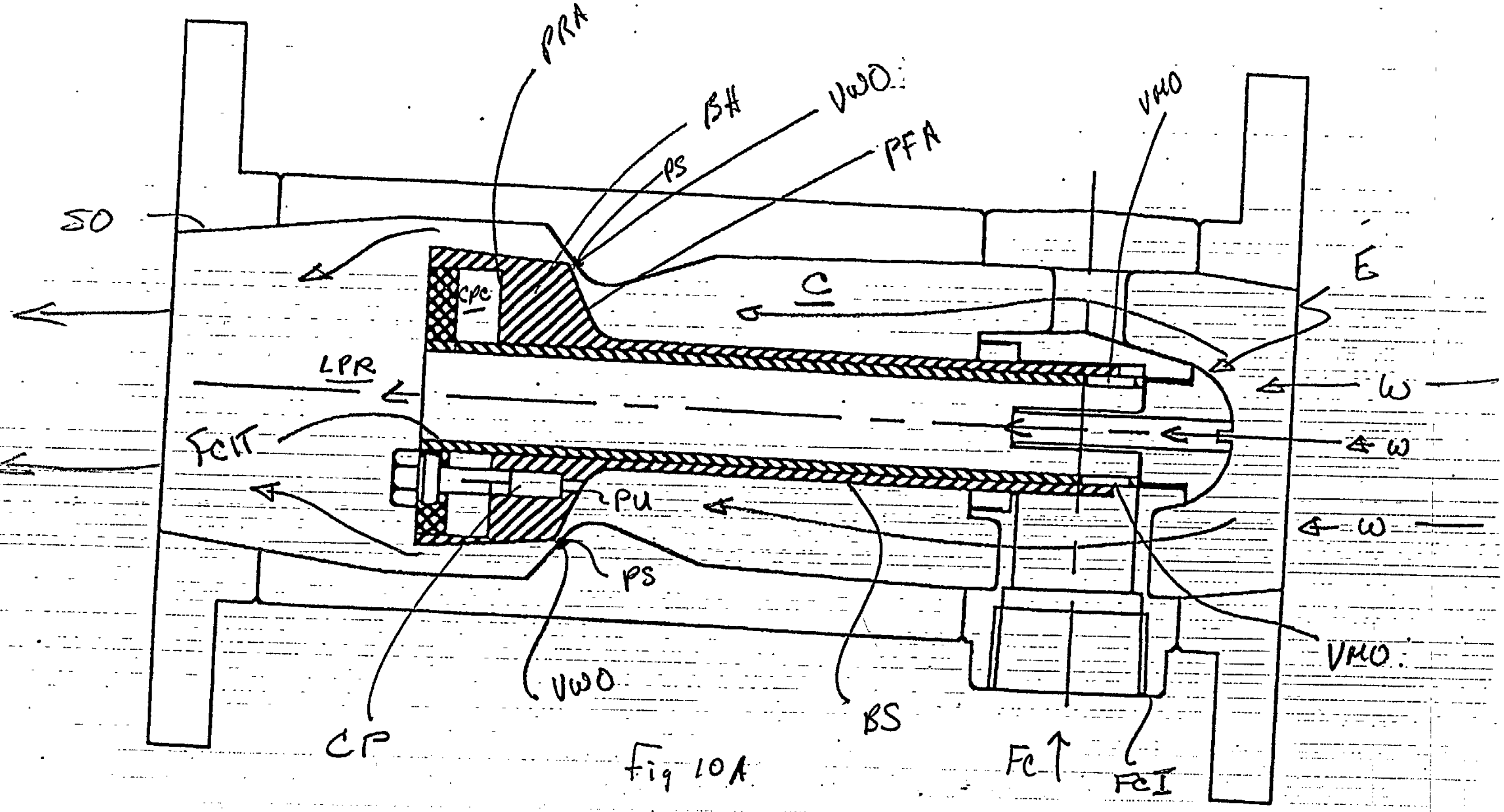

PRA
BH
VWO
PS
PFA
VMO
SO
CPC
C
E
LPR
W
W
FCIT
PU
W
PS
VMO
VWO
CP
BS
Fc
FcI

Fig 10A

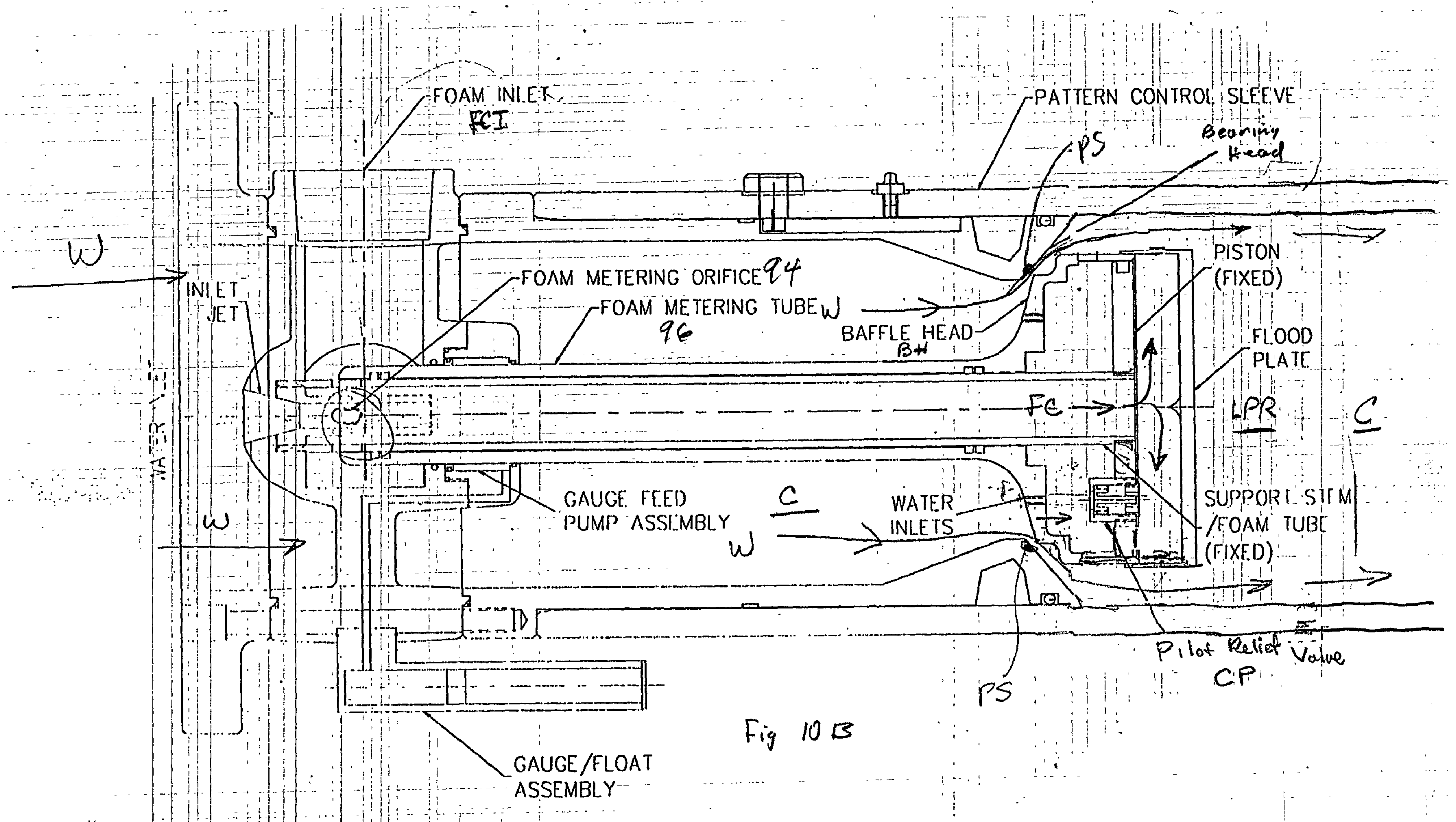

FOAM INLET
FCI
PATTERN CONTROL SLEEVE
PS
Bearing Head
W
INLET JET
FOAM METERING ORIFICE 94
FOAM METERING TUBE W
96
PISTON (FIXED)
BAFFLE HEAD
BH
FLOOD PLATE
WATER INLET
FC
LPR
C
W
GAUGE FEED PUMP ASSEMBLY
C
WATER INLETS
SUPPORT STEM /FOAM TUBE (FIXED)
W
Pilot Relief Valve
CP
PS
GAUGE/FLOAT ASSEMBLY

Fig 10 B

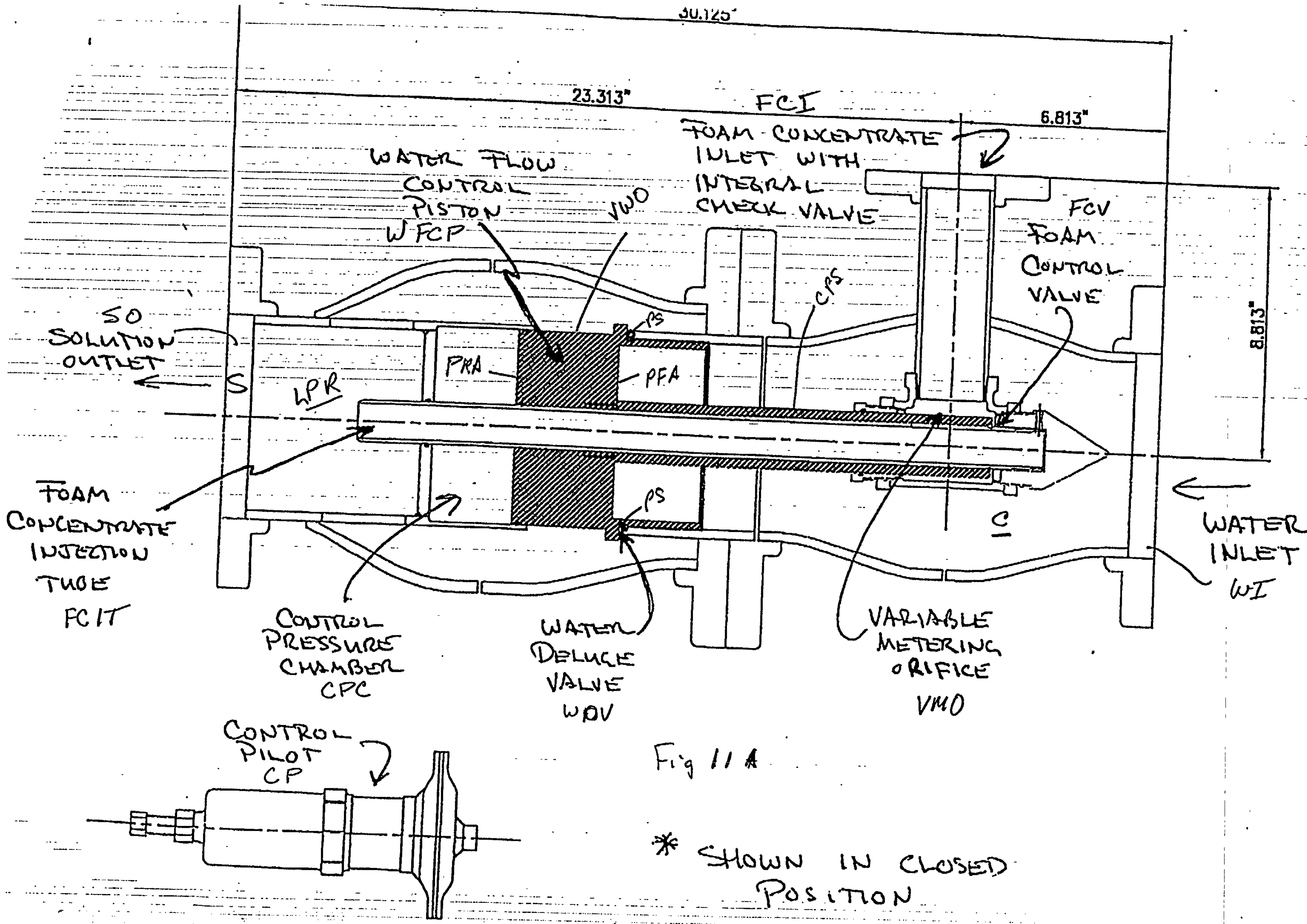
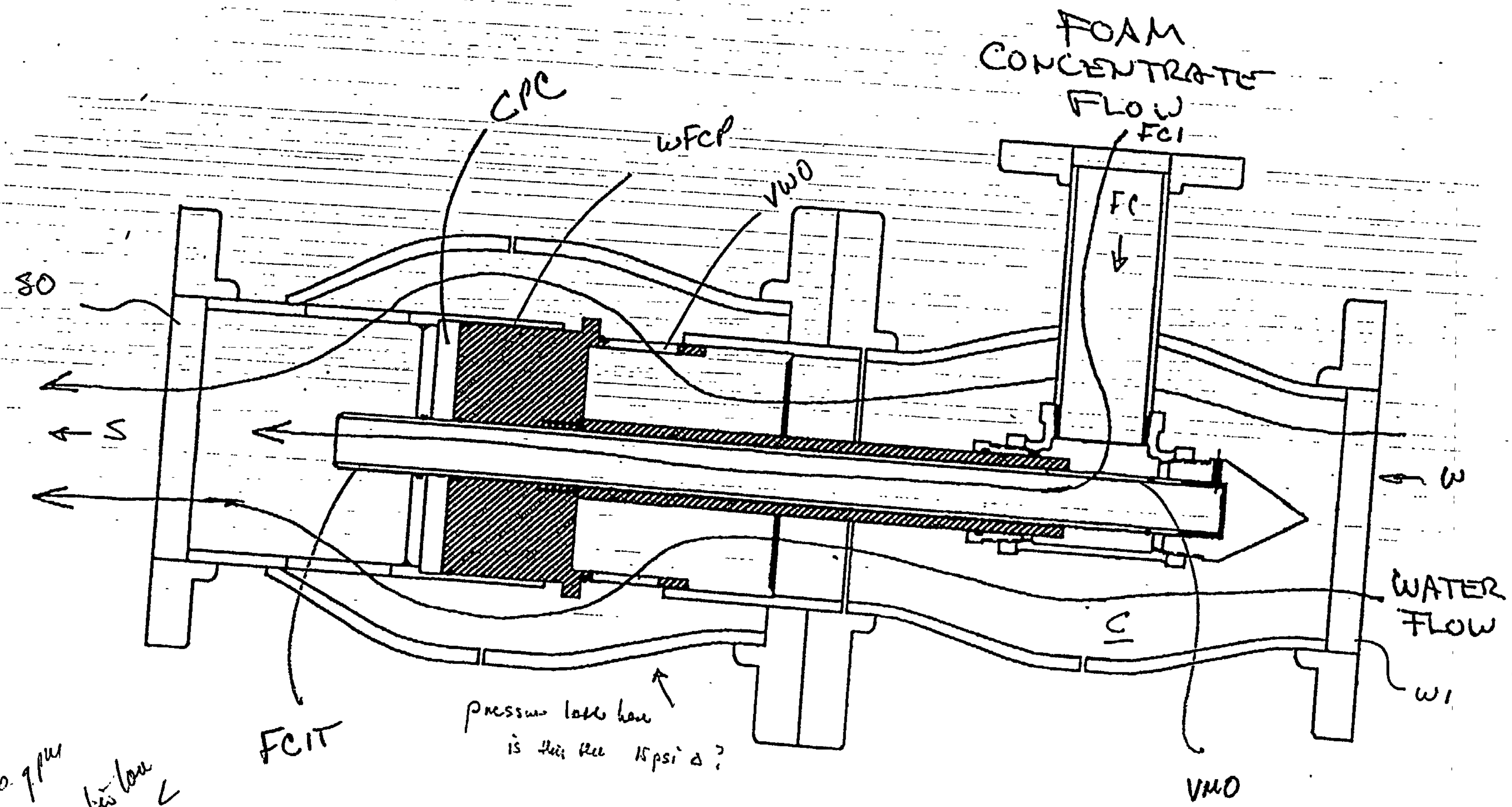


Fig 11A

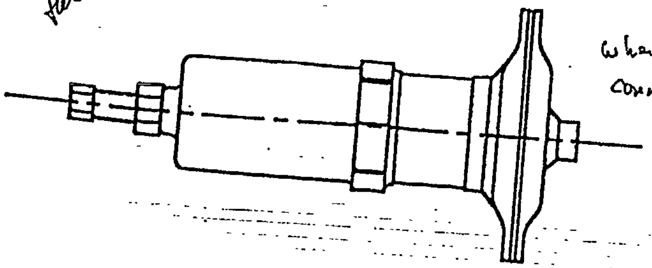
* SHOWN IN CLOSED POSITION



pressure loss here
is this the 15psi Δ?

Fig 11B

3000 gpm
tested friction loss
15psi ✓



where are the
connector fittings?

* SHOWN IN OPEN POSITION

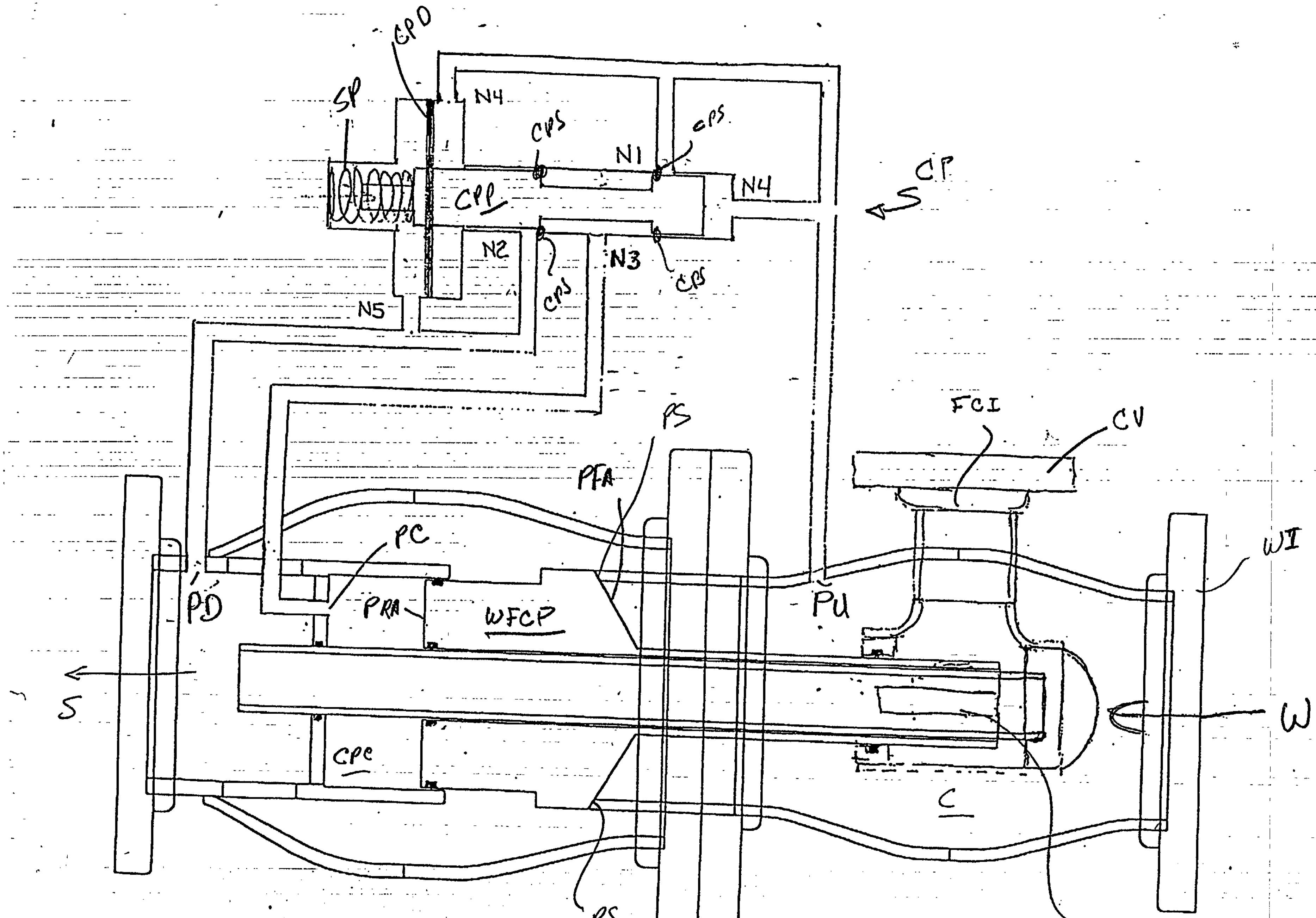
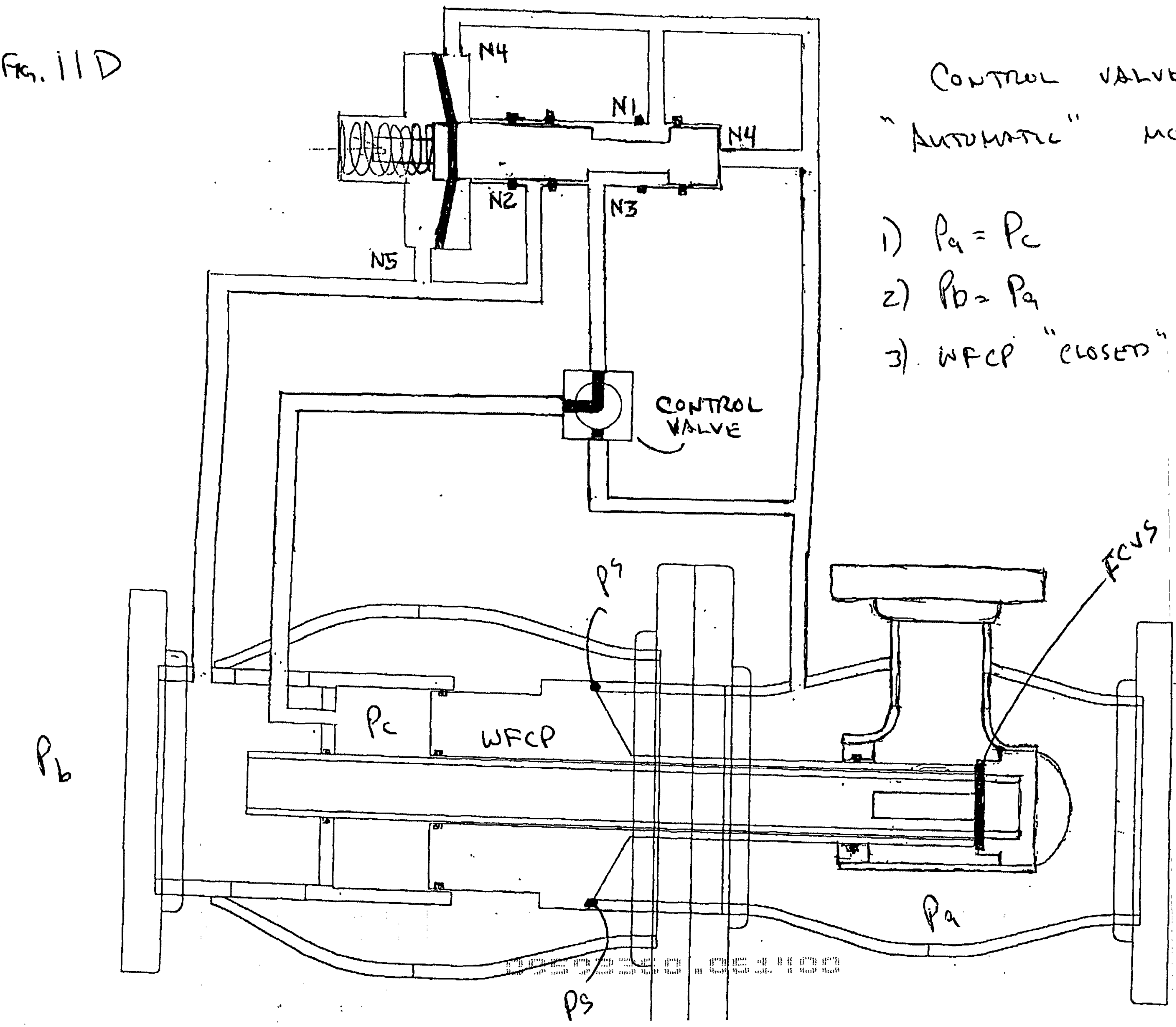

CPO
SP
N4
CPS
CPS
N1
N4
CP
CPP
N2
CPS
N3
CPS
N5
PS
FCI
CV
PFA
PC
WI
PD
PRA
WFCP
PU
S
W
CPC
C
PS
VMO

FIG 4B

Fig. 11D



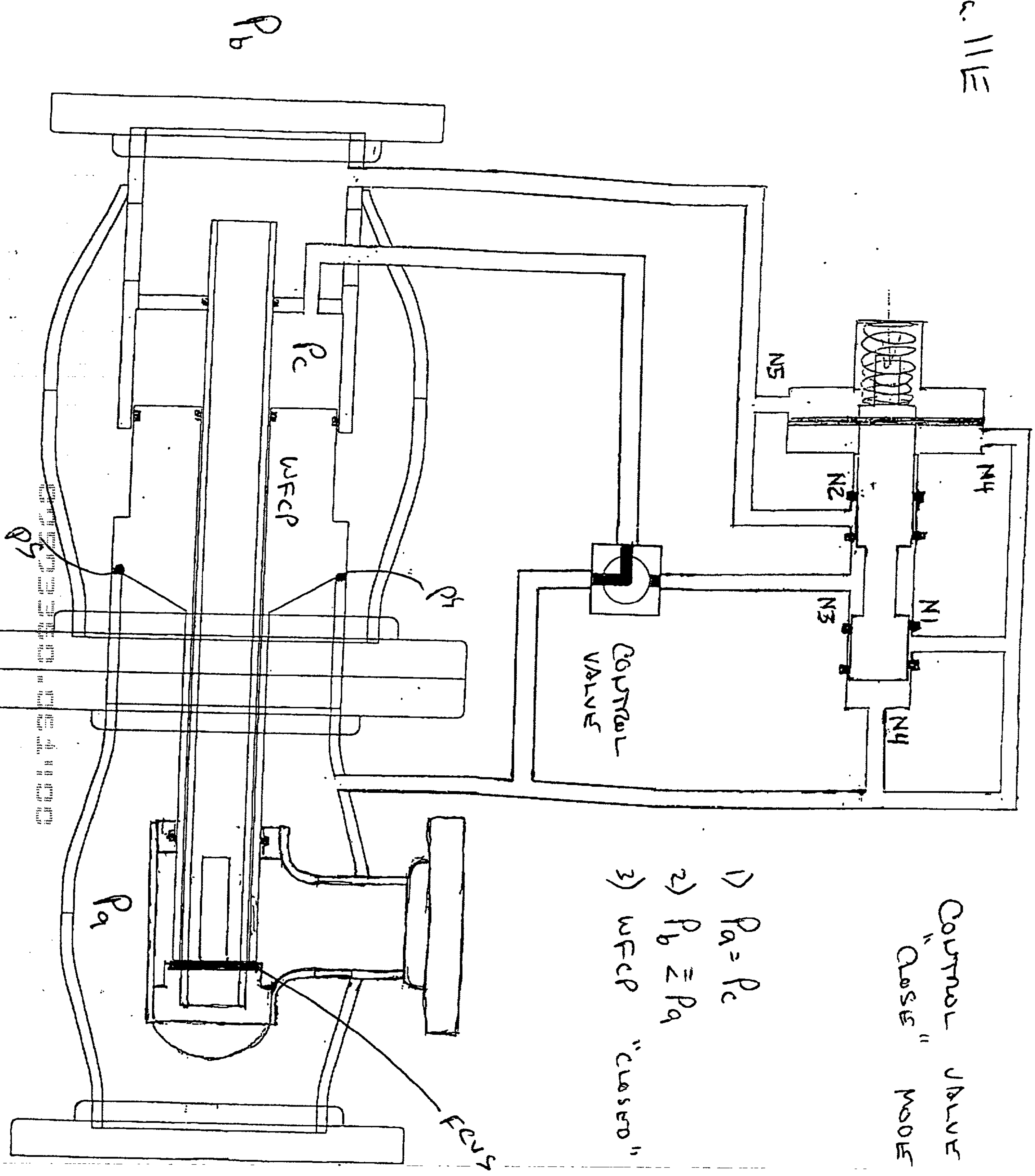
CONTROL VALVE IN "AUTOMATIC" MODE

1) $P_a = P_c$

2) $P_b = P_a$

3) WFCP "CLOSED"

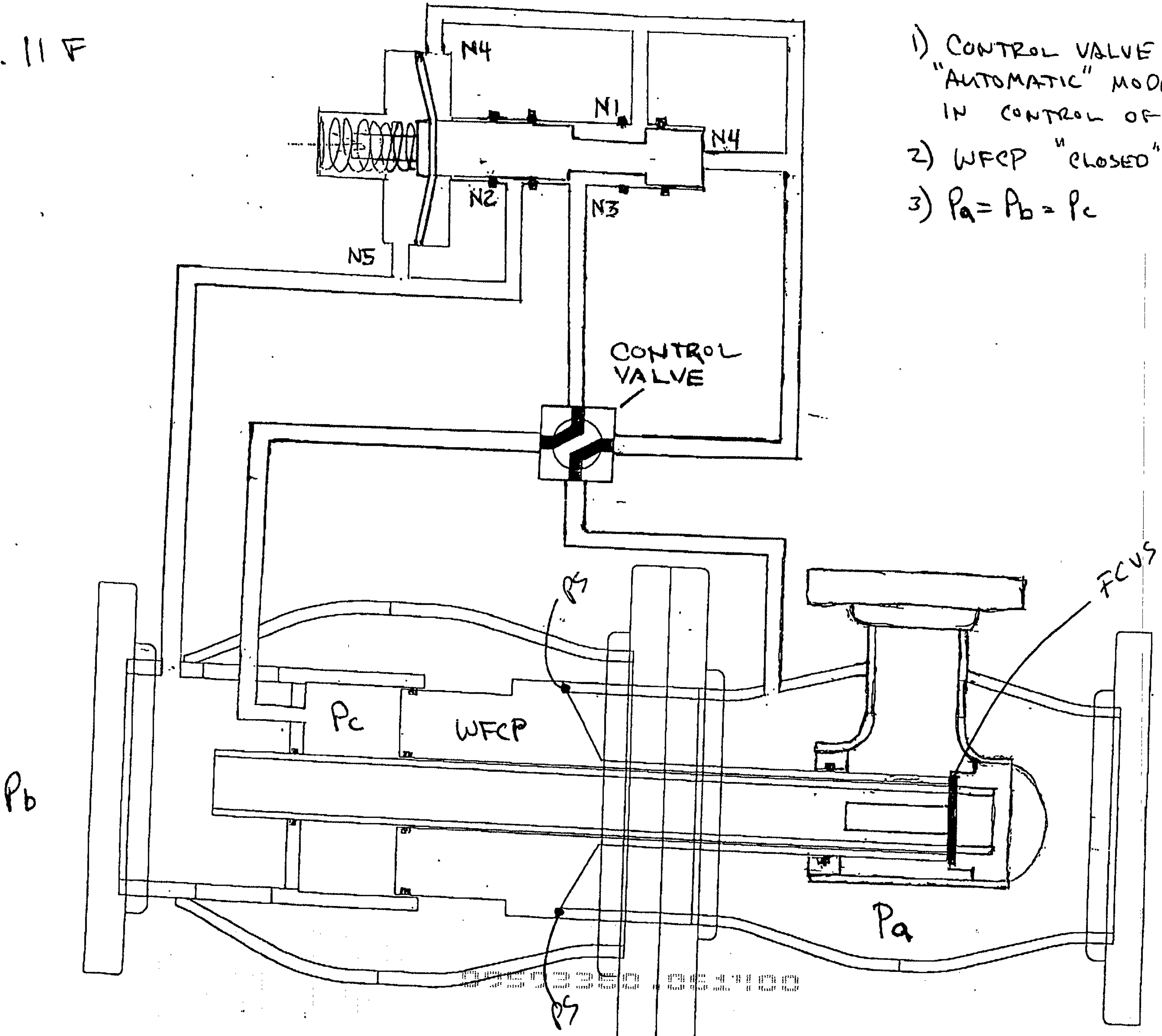
FIG. 11E



CONTROL VALVE IN "CLOSE" MODE

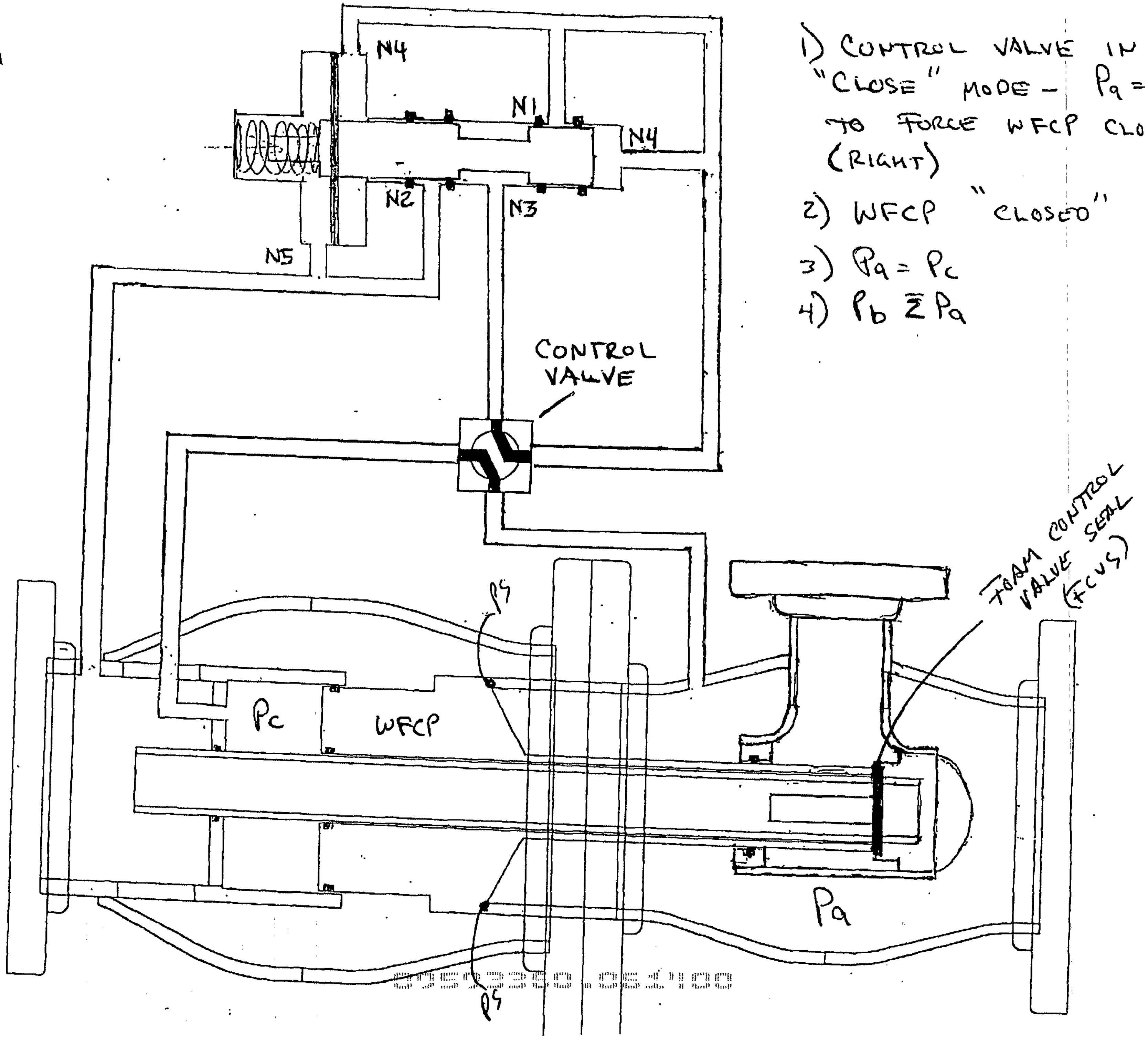
1) $P_a = P_c$
2) $P_b \geq P_a$
3) WFCP "CLOSED"

Fig. 11 F



1) CONTROL VALVE IN "AUTOMATIC" MODE - PILOT IN CONTROL OF WFCP
2) WFCP "CLOSED"
3) $P_a = P_b = P_c$

FIG. 11G



1) CONTROL VALVE IN "CLOSE" MODE – $P_a = P_c$ TO FORCE WFCP CLOSED (RIGHT)

2) WFCP "CLOSED"

3) $P_a = P_c$

4) $P_b \overline{Z} P_a$

Fig. 11 H

1) Control valve in "Automatic" mode - Pilot in control
2) $P_a = P_c$
3) $P_b \neq P_a$
4) WFCP "closed"